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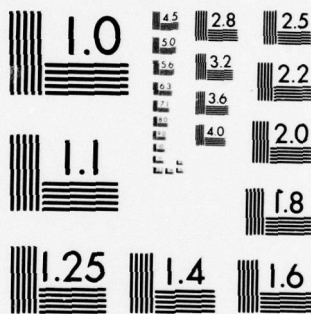
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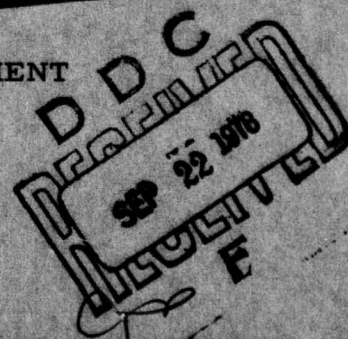
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October, 1977

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER (9) Rept. for Jan 76-Feb 77	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ADS REPORT #1 NORPAX ADS Report Number 1.	5. TYPE OF REPORT & PERIOD COVERED (12) 8p.	
7. AUTHOR(s) (10) Steven Paxan	6. PERFORMING ORG. REPORT NUMBER 77-19	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Scripps Institution of Oceanography La Jolla, CA 92093	8. CONTRACT OR GRANT NUMBER(s) (15) N00014-75-C-0152	
11. CONTROLLING OFFICE NAME AND ADDRESS Office of Naval Research Arlington, VA 22217	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS (11) Oct 77	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (14) SIO-REF-77-19	12. REPORT DATE August 1978	
	13. NUMBER OF PAGES 79 pages	
	15. SECURITY CLASS. (of this report) Unclassified	
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE		
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release: distribution unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) During the ADS meeting of March 16, 1977 it was decided to produce a NORPAX ADS program da-a report for trimonthly periods roughly corresponding to seasons. This is the first issue of that data report, and contains contour maps of...		

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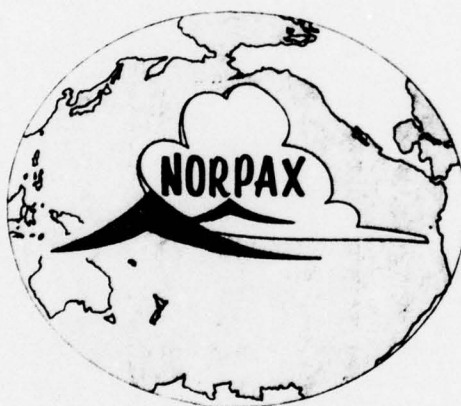
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INTRODUCTION

During the ADS meeting of March 16, 1977 it was decided to produce a NORPAX ADS program data report for trimonthly periods roughly corresponding to seasons.

This is the first issue of that data report, and contains contour maps of monthly meaned: FNWC air temperature, sea temperature, wind speed, wind direction, surface vapor pressure, and 700 mb heights; NORPAX calculated wind stress, wind stress curl, wind shear velocity cubed (U^3), ^{U-cubed} sensible heat flux, latent heat flux; objectively analyzed TRANSPAC temperatures at discrete depths from White and Bernstein (SIO). This report also contains monthly drifter buoy displacement vectors from Kirwan (TAMU) and McNally (SIO).

Because of extensive back dating in this first report, the time period from June, 1976 to February, 1977 will be covered.

PROCEDURE AND ANALYSIS

1. FNWC 63 x 63 Northern Hemispheric Fields

FNWC data were taken from 63 x 63 polar gridded fields of 6-hourly wind speed and direction, and 12-hourly 700 mb height, sea surface temperature, air temperature, and vapor pressure.

33 x 63 fields were extracted from the larger fields; geographic coverage of a 33 x 63 field is shown in Figure 1. 10-m level winds and U_{10}^3 were calculated from FNWC winds by an iterative scheme using the neutral flux-profile relationships obtained by Businger et al. (1971). Wind stress was calculated from FNWC wind speed and direction using a bulk aerodynamic equation:

$$\tau = -\rho \overline{uw} = \rho C_D U_{10}^2 \quad (1)$$

where

τ = surface stress

\overline{uw} = Reynolds stress, ($m^2 sec^{-2}$)

ρ = air density

U_{10} = wind speed at 10 m

$C_D = .1.3 \times 10^{-3}$ (drag coefficient found by Smith and Banke (1975) for $U_{10} = 10$ m/sec).

The vertical component of wind stress curl was calculated on the FNWC northern hemispheric grid using polar projection mapping equations and finite difference approximations (Appendix A).

Sensible heat flux (cal/cm sec) was obtained using an empirical bulk formula (Friehe and Schmitt, 1976):

$$S.H.F. = \rho C_p [0.2 \times 10^{-6} + C_H \cdot U_{10} \cdot (T_s - T_A)] \quad (2)$$

where,

$$C_p = 0.24 \text{ cal/gm}^\circ\text{C}$$

$$C_H = 0.91 \times 10^{-7}$$

$$T_s = \text{sea surface temperature}$$

$$T_A = (10 \text{ meter}) \text{ air temperature}$$

The latent heat flux ($\text{cal/cm}^2\text{sec}$) was also calculated from a bulk formula (Friehe and Schmitt, 1976):

$$\text{L.H.F.} = L \cdot C_E \cdot U_{10} \cdot [Q_{\text{SEA}} - Q] \quad (3)$$

$$L = 595 \text{ cal/gm (heat of evaporation)}$$

$$C_E = 1.32 \times 10^{-3}$$

$$Q = 0.75 [E_{\text{AIR}} (\text{gm} \cdot \text{m}^{-3}) = \text{FNWC vapor pressure}]$$

$$Q_{\text{SEA}} = \text{vapor density near the sea surface} \\ = 1.667 \times 10^{-7} [e^{17.19[(T_s + 273)/273]}]$$

Stress, stress-curl and U_z^3 fields were calculated at 00z, 06z, 12z, 18z GMT; heat fluxes were calculated for 00z and 12z GMT every day. These calculated fields were then averaged to obtain daily, 5-daily, and monthly means. North and east-wind components were meaned to obtain daily, 5-daily, and monthly vector means of wind speed and direction. Monthly means were contoured over the region of the North Pacific from 120E to 230E and 20N to 60N. These contour maps are grouped by month in the present report in Figures 2.1-2.11, 4.1-4.11, 7.1-7.11, 10.1-10.11, 13.1-13.11, 16.1-16.11, 19.1-19.11, 22.1-22.11, and

24.1-24.11.

2. Objectively Analyzed Transpac XBT

XBTs have been regularly dropped from ships of opportunity in the Pacific since 1974. Recovered temperature profile data have been analyzed at Scripps by Bernstein and White and temperature residuals from their 1968 to 1974 climatology calculated. These temperature anomalies were contoured for 0, 60, 120, 200, 300 and 400 meter depths, by month, in Figures 3.1-3.6, 5.1-5.6, 8.1-8.6, 11.1-11.6, 14.1-14.6, 17.1-17.6, 20.1-20.6, 23.1-23.6, and 25.1-25.6.

3. Kirwan/McNally Buoys

Several buoys drogued at 35 meters were deployed in the North Pacific ADS area from June, 1976 to the present. Because of attrition of old buoys and addition of new buoys, the number at any time varied from 12 to 26. Satellite fixes were obtained on each buoy several times a day; although the analyses of these data were not complete, monthly instantaneous buoy positions were available up to December, 1976. Monthly buoy displacement vectors have been plotted in Figures 6., 9., 12., 15., 18., and 21. Because the buoys were deployed in June, 1976, there are no buoy displacement data for that month.

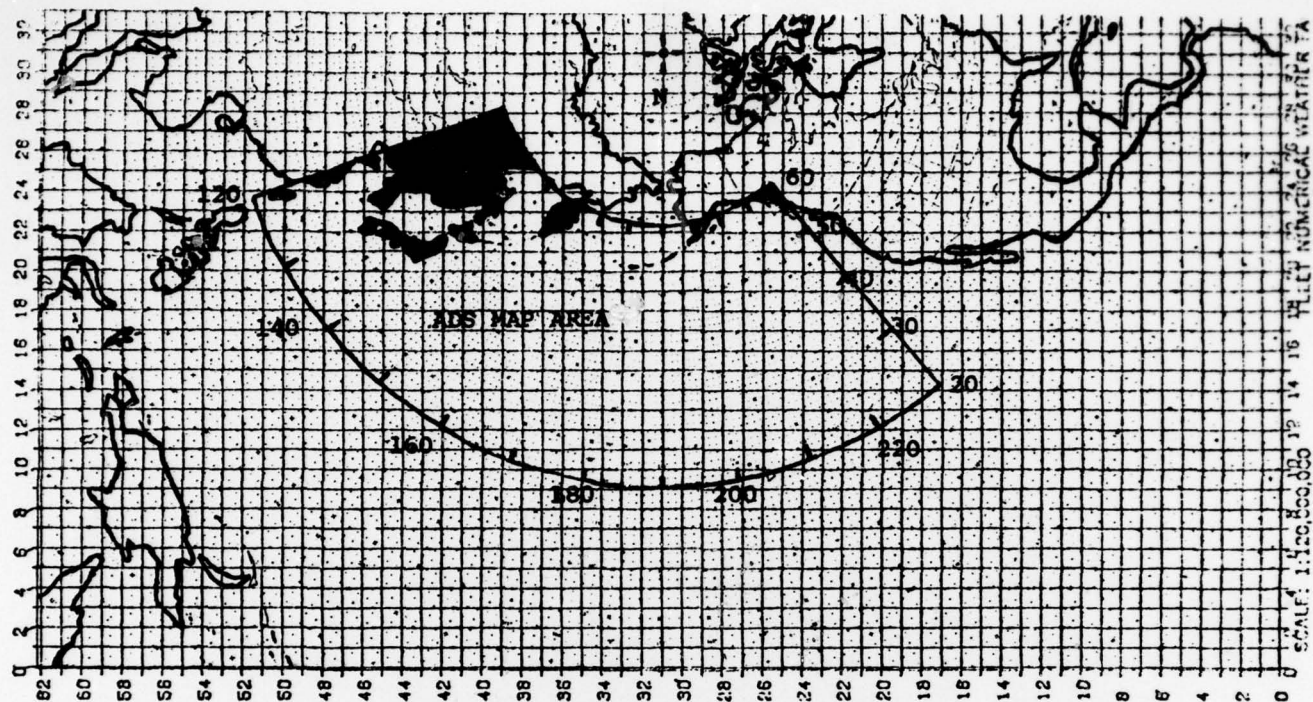


FIGURE 1. 33 x 63 field geographic coverage. The area of the ADS contour maps is as indicated. This map is a polar projection of the northern hemisphere.

WIND SPEED (M/SEC)

JUN 76

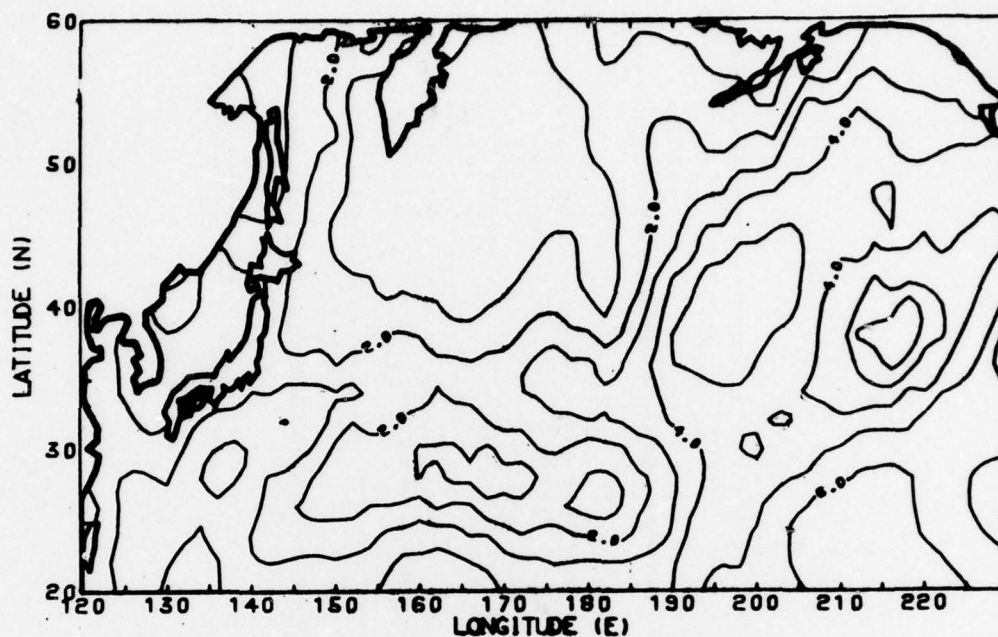


FIGURE 2.1

Absolute value of monthly mean vector wind velocities at 19.5 meters.
Contour intervals are 1 m/sec.

WIND DIRECTION

JUN 76

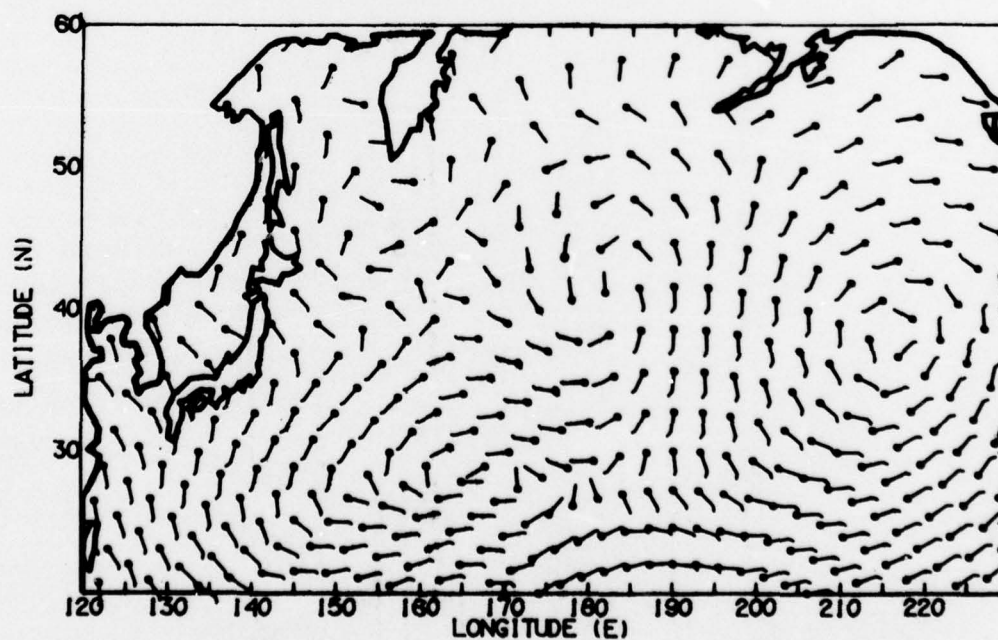


FIGURE 2.2

Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vane on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

WIND STRESS (DYNES/CM²)

JUN 76

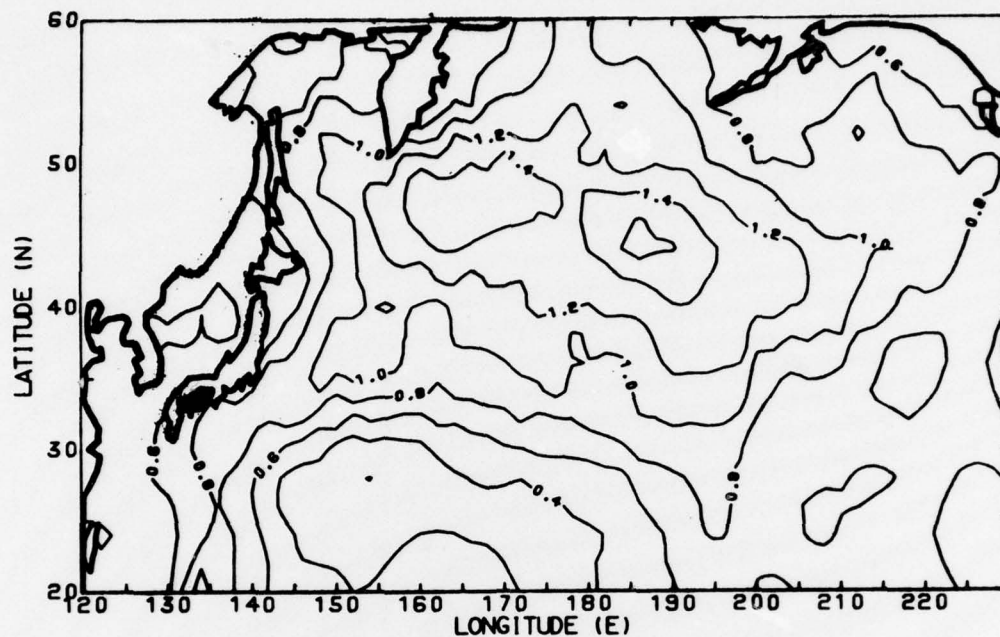


FIGURE 2.3 Monthly mean wind stress is the mean of 6-hourly wind stress at 10 meters calculated from FNWC wind data. Contour intervals are 0.2 dynes/cm².

CURL OF WIND STRESS (10⁻⁹ DYNES/CM³)

JUN 76

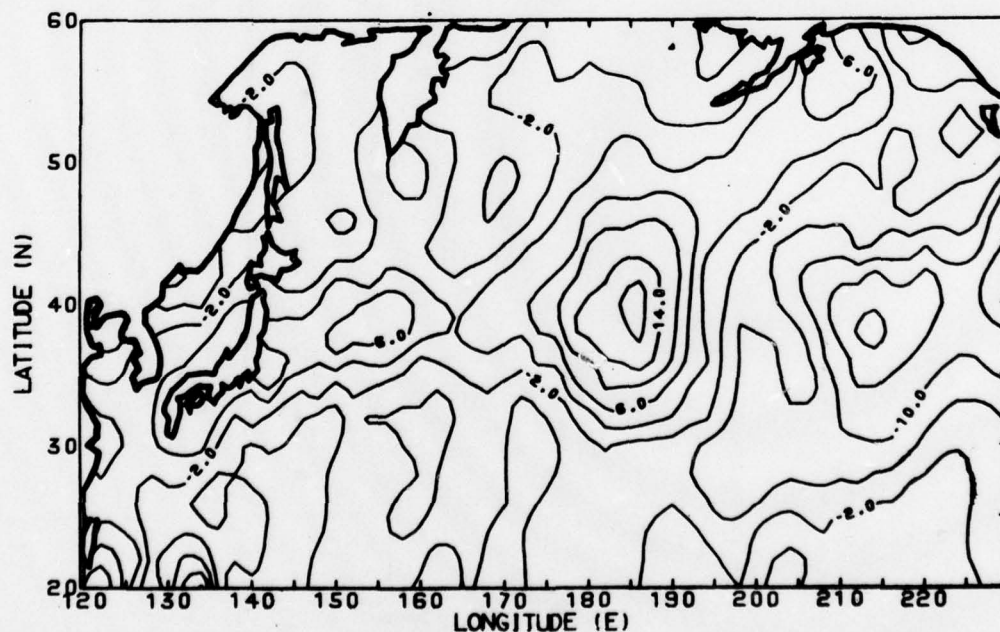


FIGURE 2.4 The vertical component of monthly mean wind stress curl is the mean of 6-hourly wind stress curl approximated by finite-differences from 6-hourly wind stresses at 10 meters. Isolines of zero curl are plotted heavily, and contour intervals are 4.0×10^{-9} dynes/cm³.

U STAR CUBED ((M/SEC)**3)

JUN 76

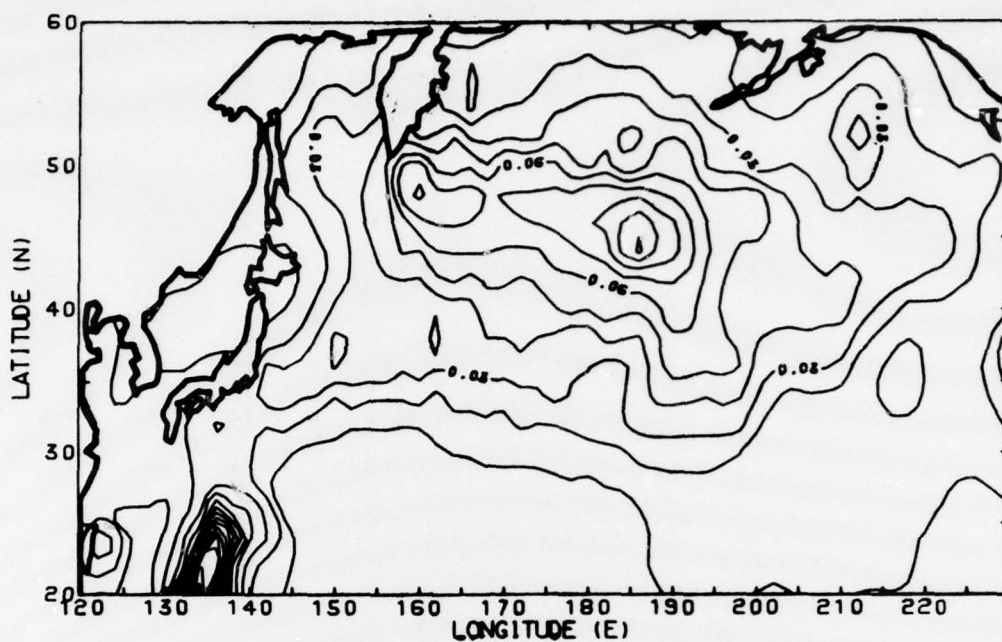


FIGURE 2.5 Monthly mean wind shear stress velocity cubed, U_*^3 is the mean of 6-hourly wind shear stress velocity cubed calculated from wind speed at 10 meters. Contour intervals are 0.01 (m/sec)³.

SEA SURFACE TEMPERATURE (DEG.C)

JUN 76

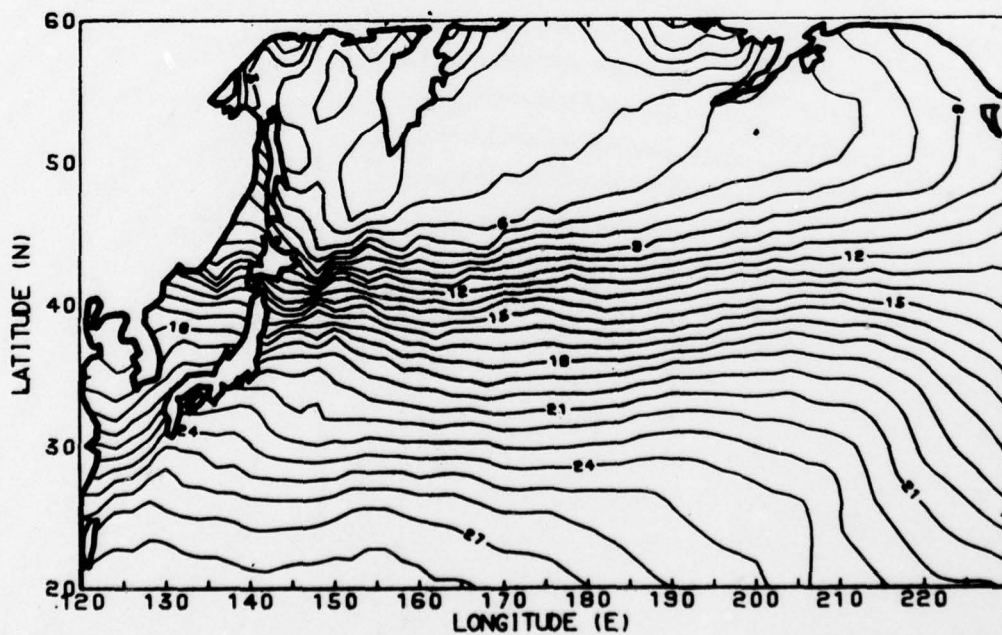


FIGURE 2.6 Monthly mean sea surface temperature is the mean of 12-hourly FNWC sea surface temperatures. Contour intervals are 1°C.

AIR TEMPERATURE (DEG. C) JUN 76

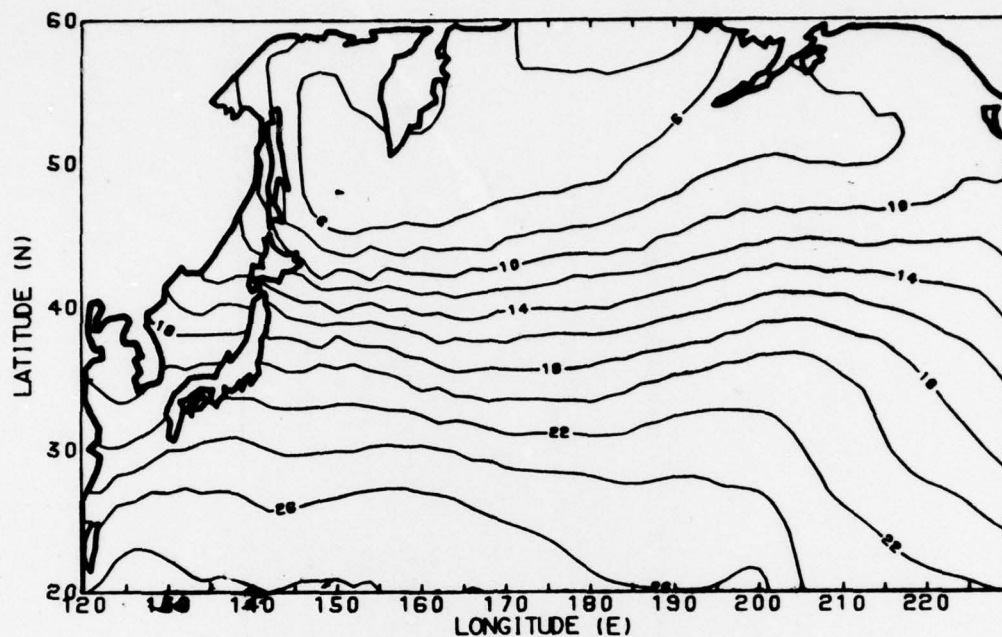


FIGURE 2.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) JUN 76

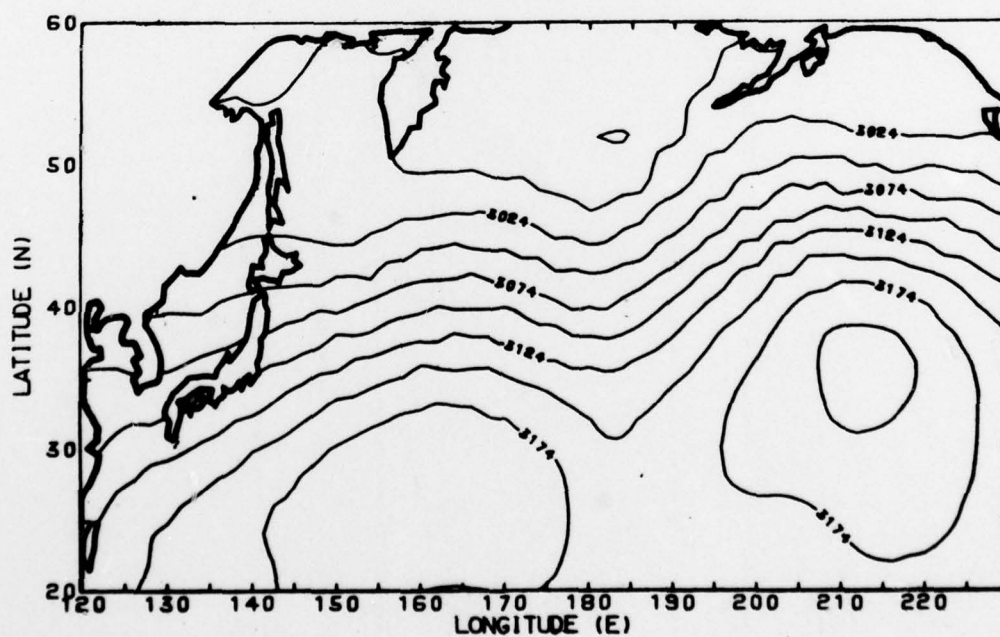


FIGURE 2.8 Monthly mean 700 mb height is the mean of 12-hourly FNWC 700 mb heights. Contour intervals are 25 meters.

VAPOR PRESSURE (MB) JUN 76

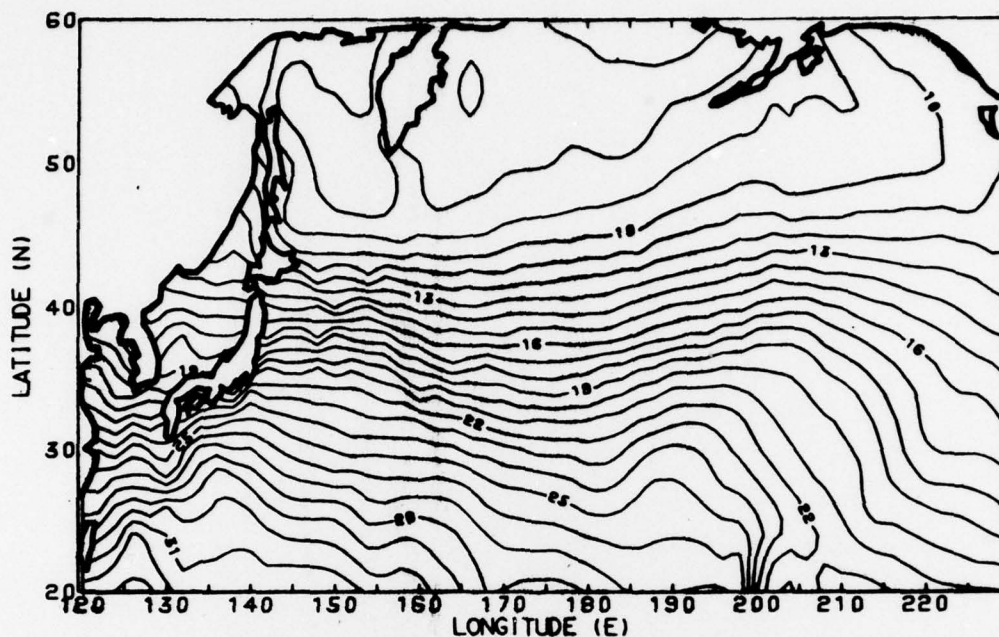


FIGURE 2.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM² SEC) JUN 76

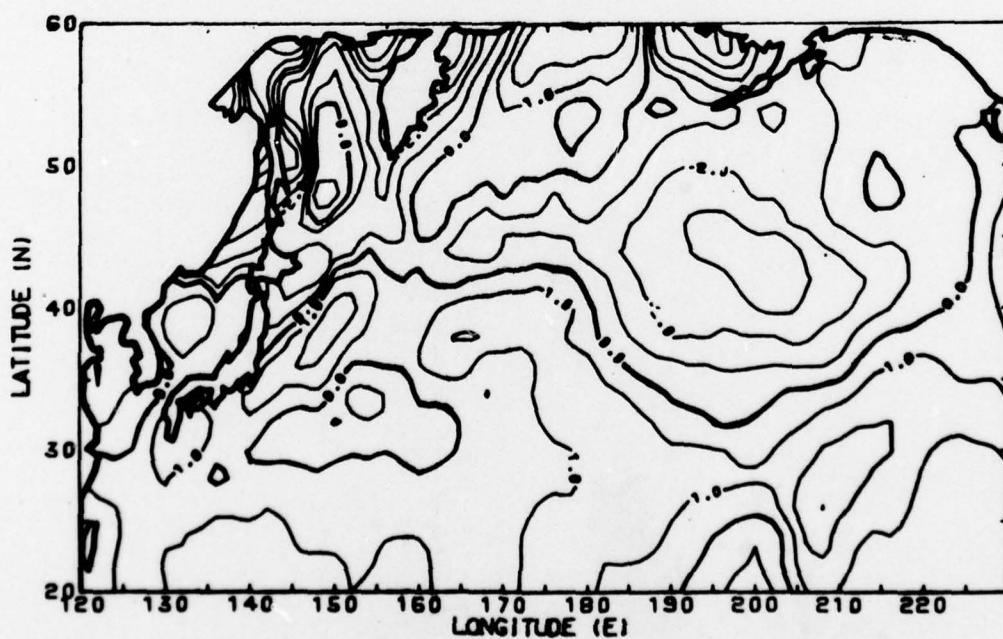


FIGURE 2.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm² sec.

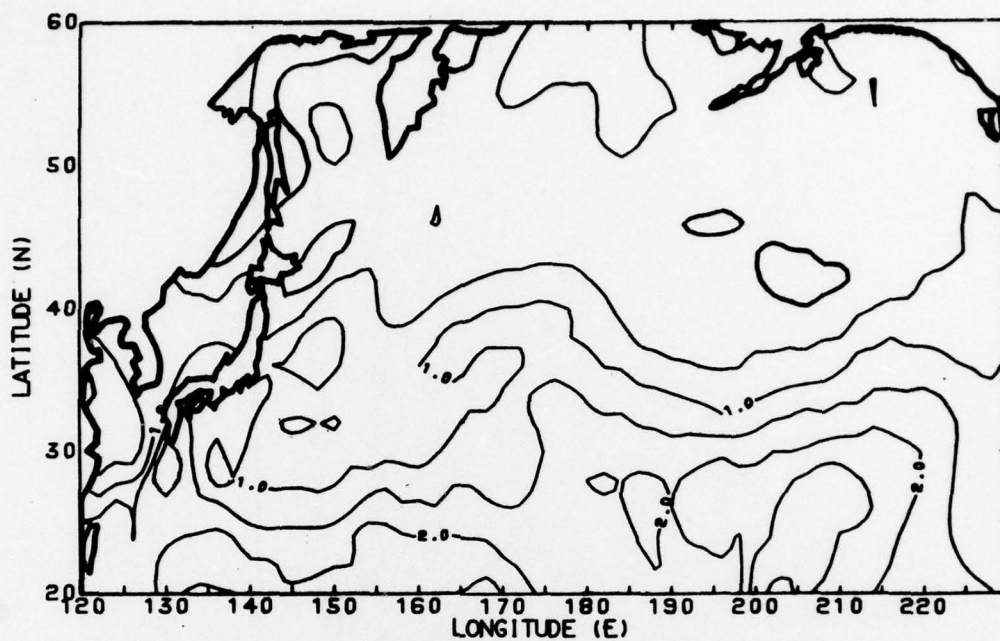


FIGURE 2.11

Monthly mean latent heat flux (ocean to atmosphere) is the mean of 12-hourly latent heat flux calculated from FNWC sea temperature, vapor pressure and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 0.5×10^{-3} cal/cm 2 sec.

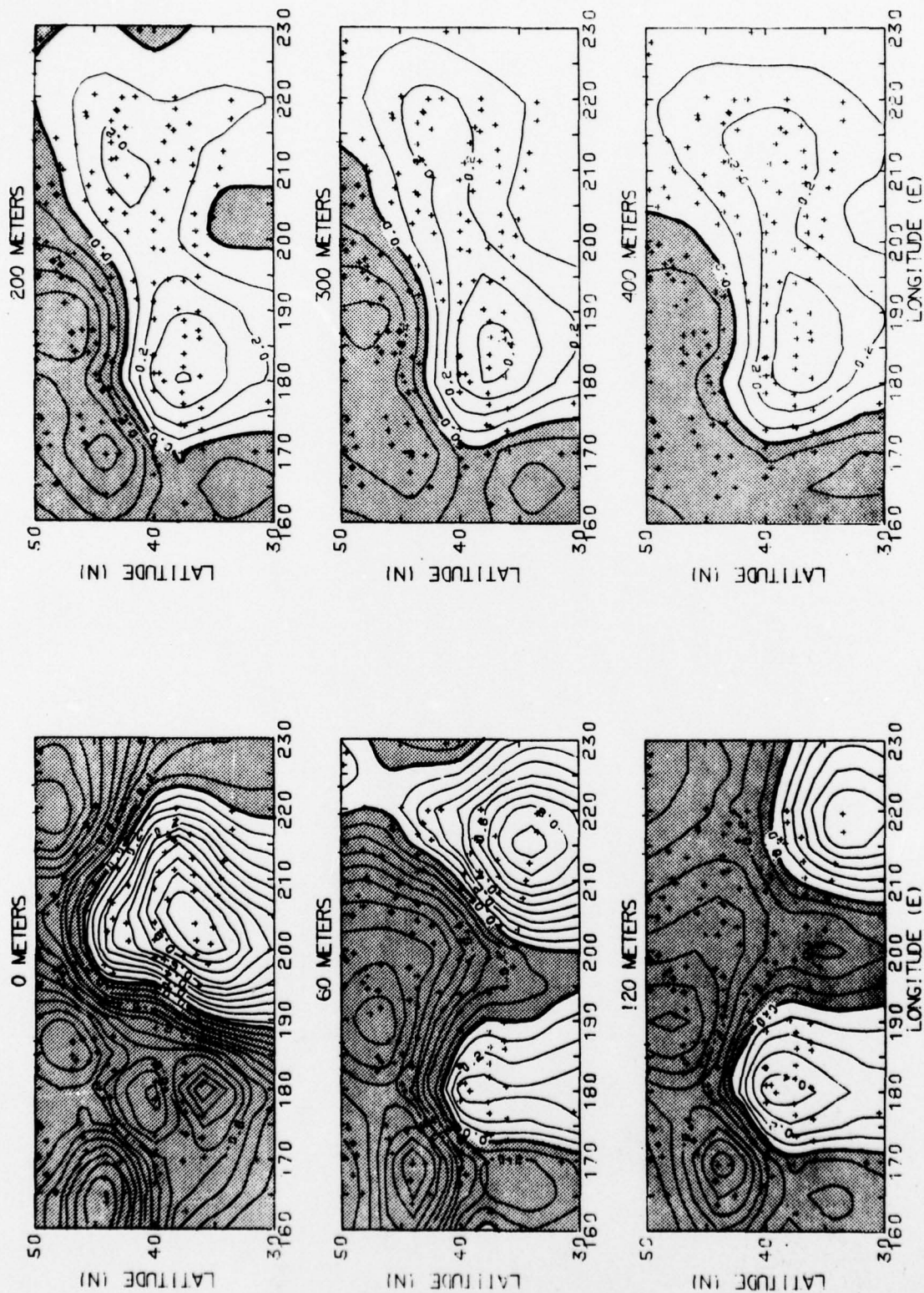


FIGURE 3.

Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

WIND SPEED (M/SEC)

JUL 76

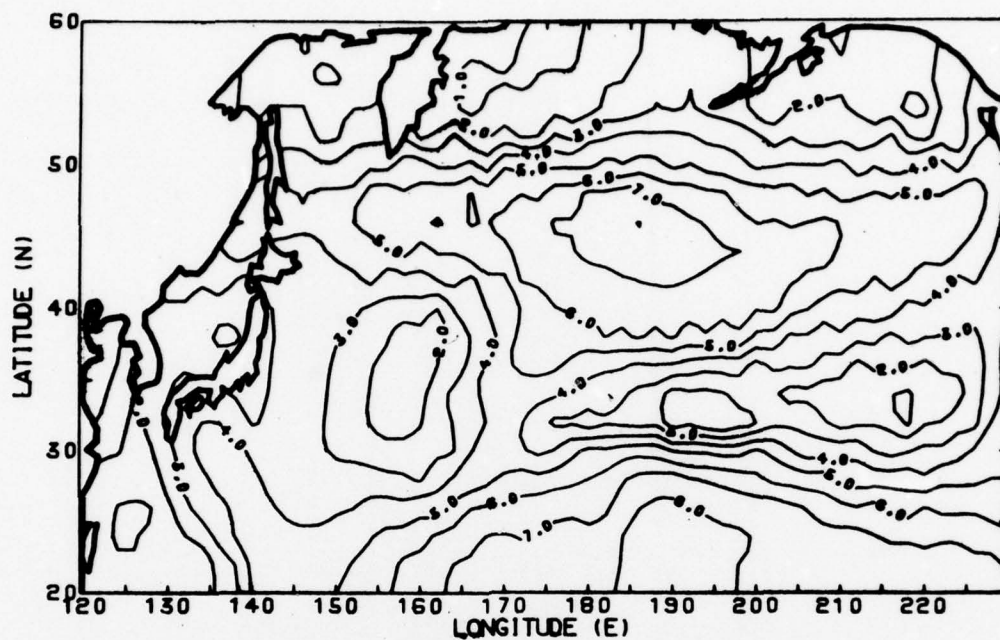


FIGURE 4.1 Absolute value of monthly mean vector wind velocities at 19.5 meters. Contour intervals are 1 m/sec.

WIND DIRECTION

JUL 76

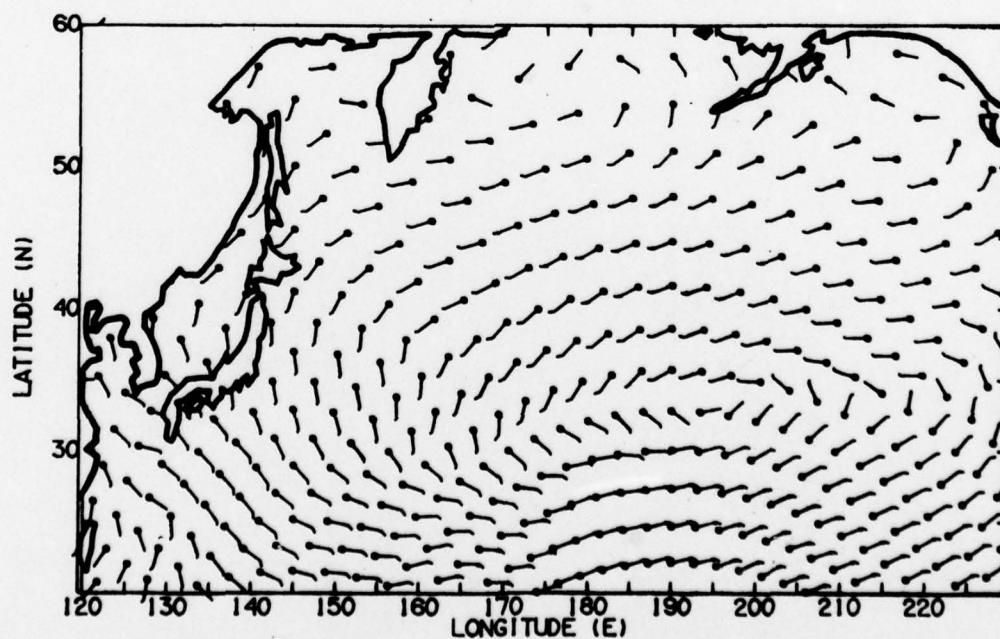


FIGURE 4.2 Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vanes on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

WIND STRESS (DYNES/CM²)

JUL 76

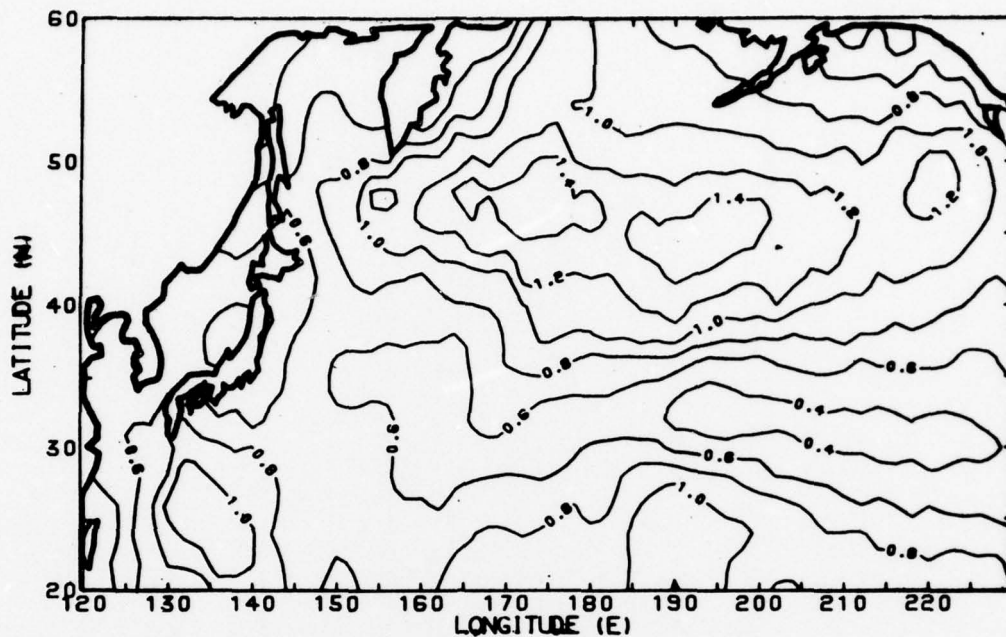


FIGURE 4.3 Monthly mean wind stress is the mean of 6-hourly wind stress at 10 meters calculated from FNWC wind data. Contour intervals are 0.2 dynes/cm².

CURL OF WIND STRESS (10^{-9} DYNES/CM²)

JUL 76

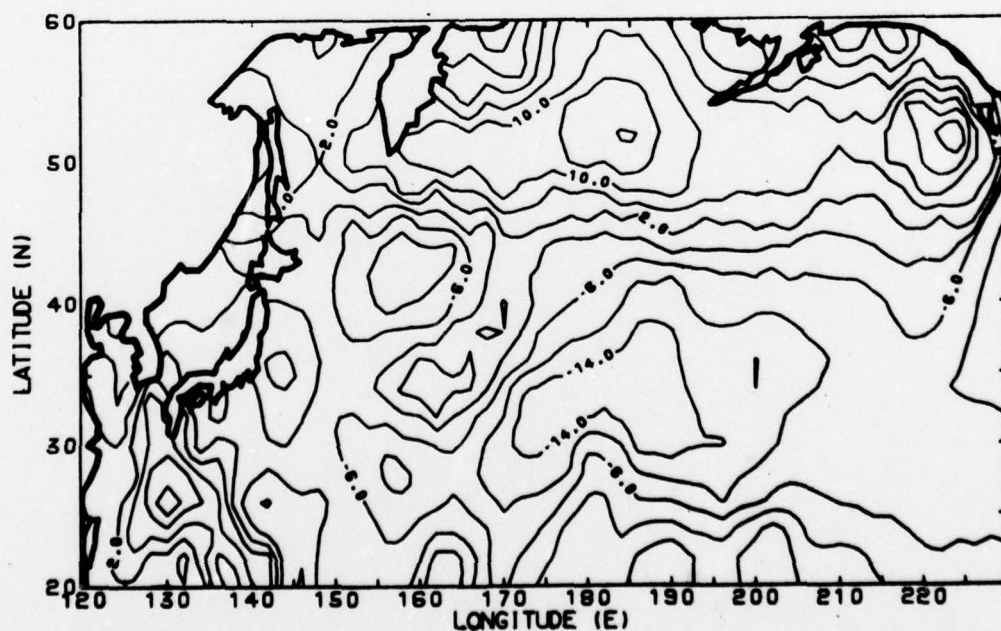


FIGURE 4.4 The vertical component of monthly mean wind stress curl is the mean of 6-hourly wind stress curl approximated by finite-differences from 6-hourly wind stresses at 10 meters. Isolines of zero curl are plotted heavily, and contour intervals are 4.0×10^{-9} dynes/cm².

U STAR CUBED ((M/SEC)**3)

JUL 76

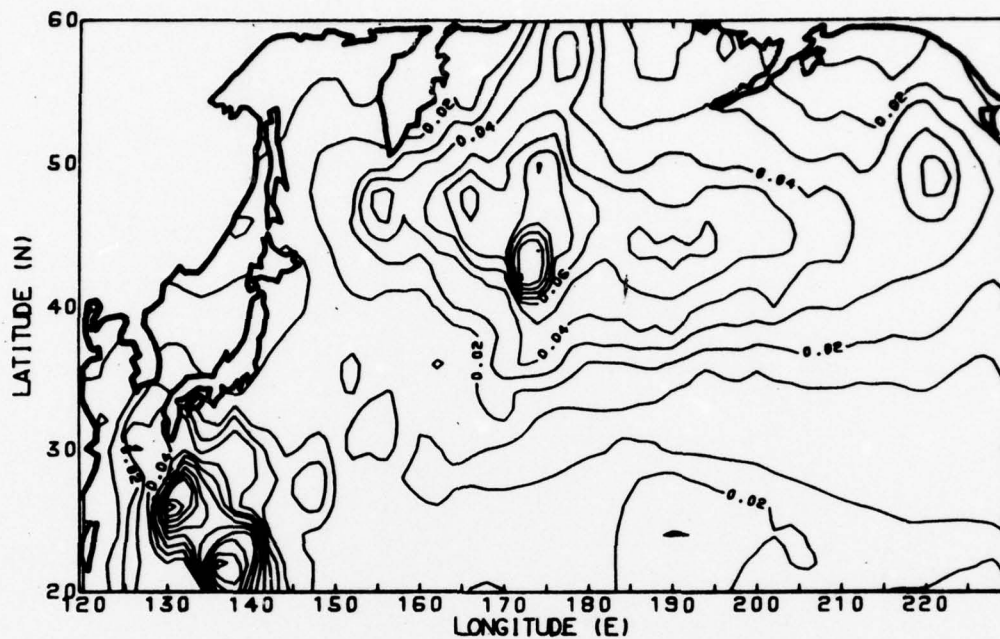


FIGURE 4.5

Monthly mean wind shear stress velocity cubed, U_*^3 is the mean of 6-hourly wind shear stress velocity cubed calculated from wind speed at 10 meters. Contour intervals are 0.06 (m/sec)^3 .

SEA SURFACE TEMPERATURE (DEG.C)

JUL 76

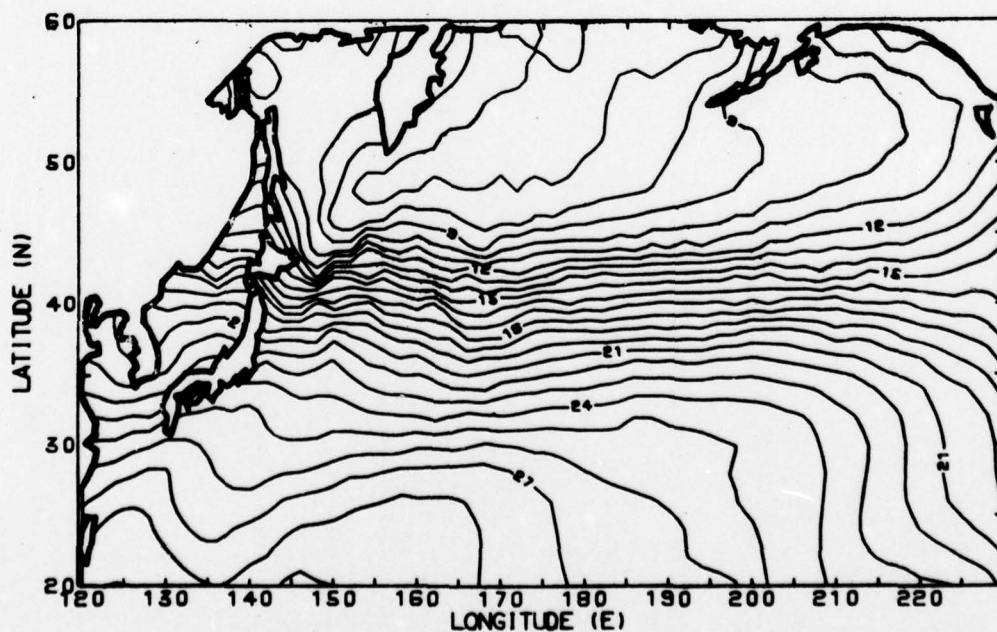


FIGURE 4.6

Monthly mean sea surface temperature is the mean of 12-hourly FNWC sea surface temperatures. Contour intervals are 1°C .

AIR TEMPERATURE (DEG. C) JUL 76

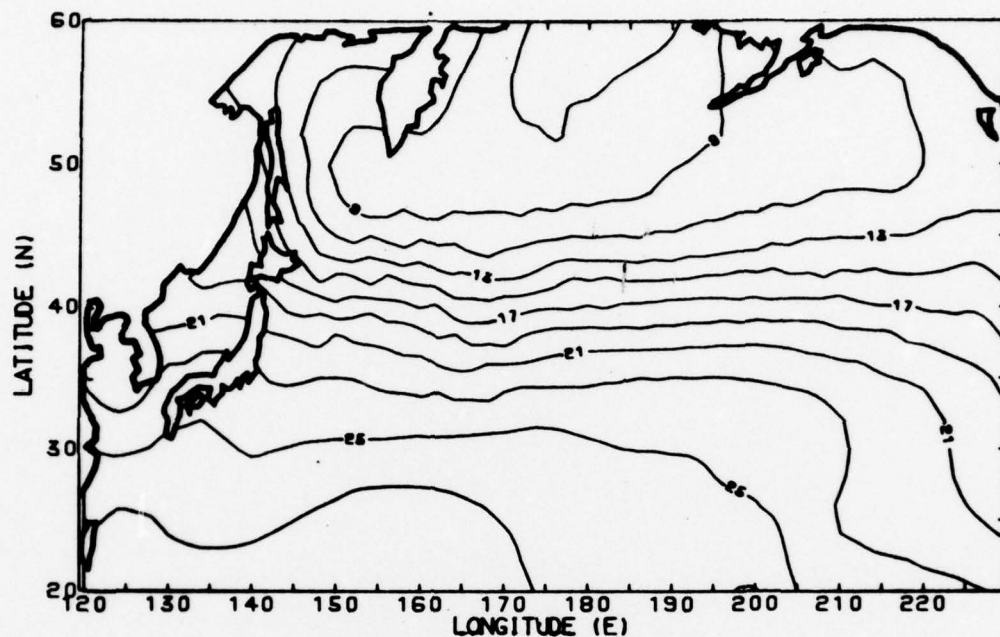


FIGURE 4.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) JUL 76

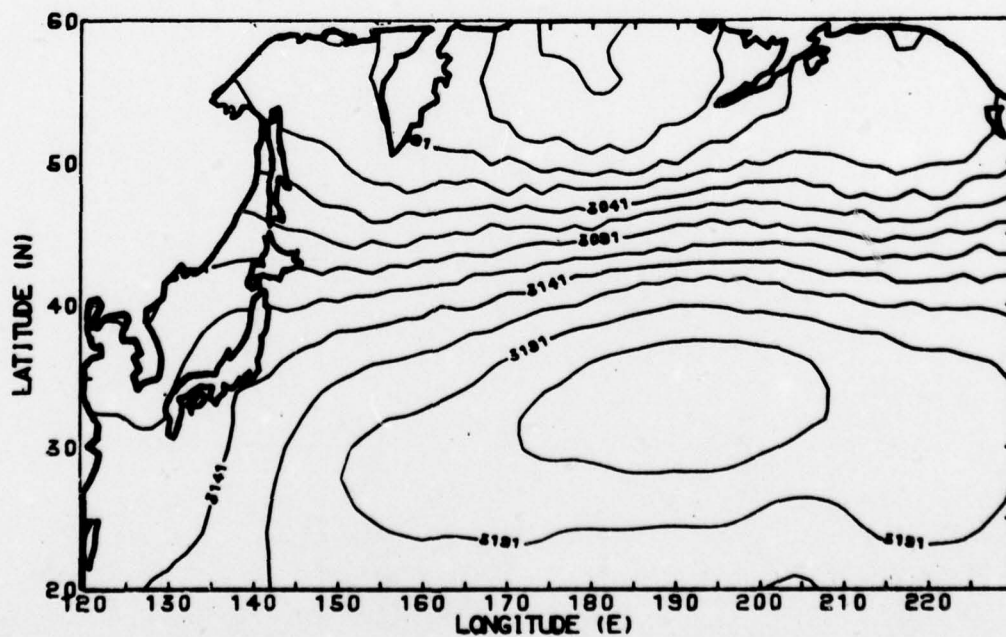


FIGURE 4.8 Monthly mean 700 mb height is the mean of 12-hourly FNWC 700 mb heights. Contour intervals are 25 meters.

VAPOR PRESSURE (MB) JUL 76

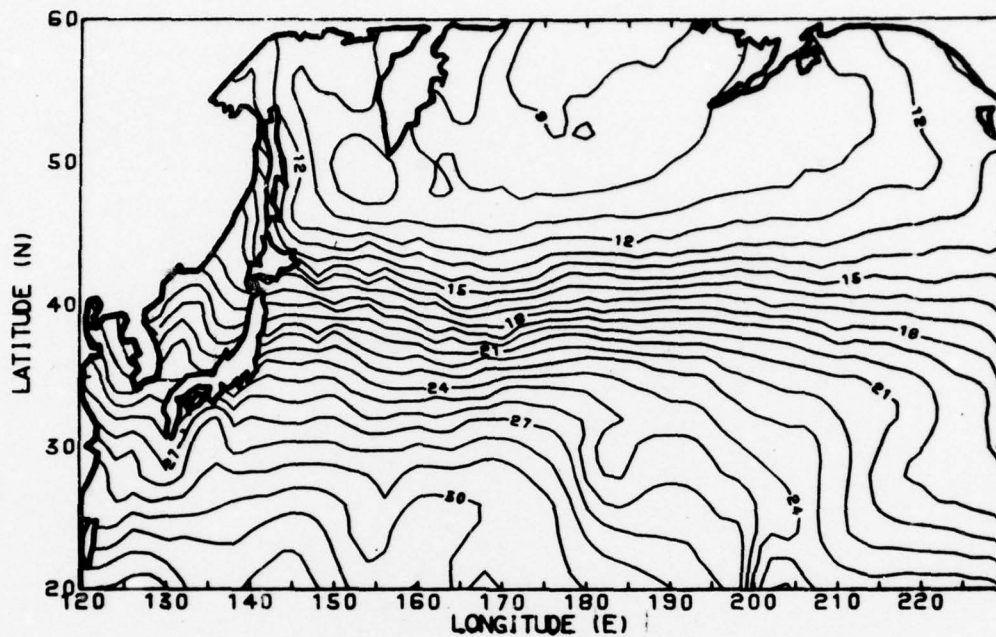


FIGURE 4.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM² SEC) JUL 76

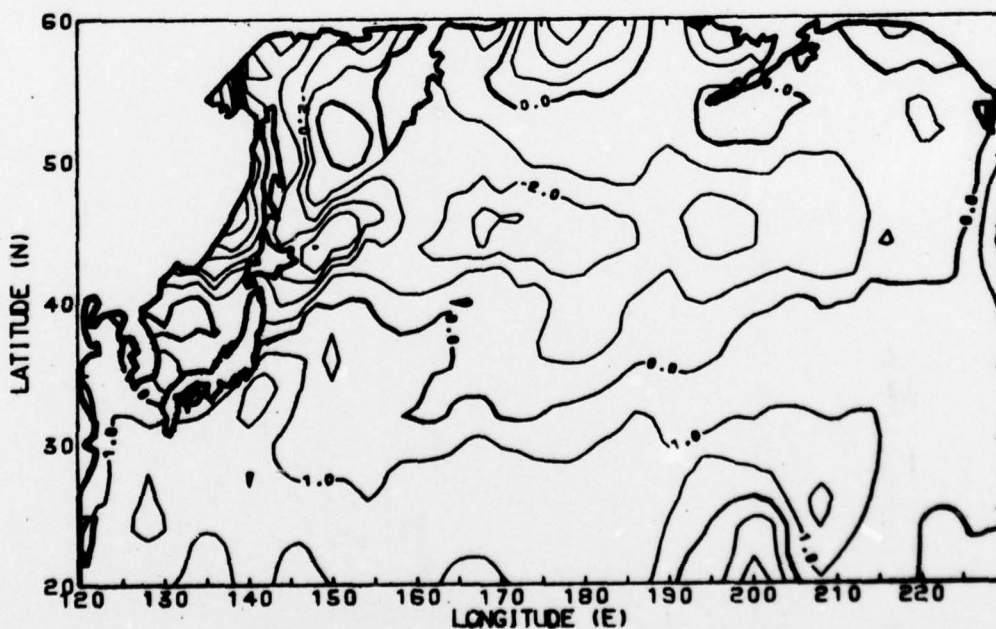


FIGURE 4.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm² sec.

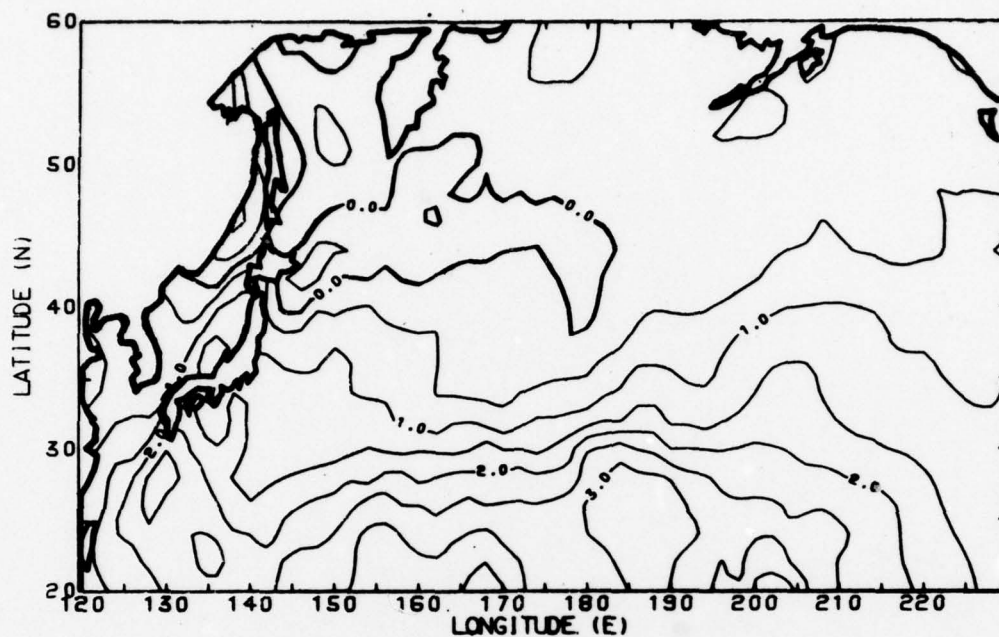


FIGURE 4.11

Monthly mean latent heat flux (ocean to atmosphere) is the mean of 12-hourly latent heat flux calculated from FNWC sea temperature, vapor pressure and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 0.5×10^{-3} cal/cm 2 sec.

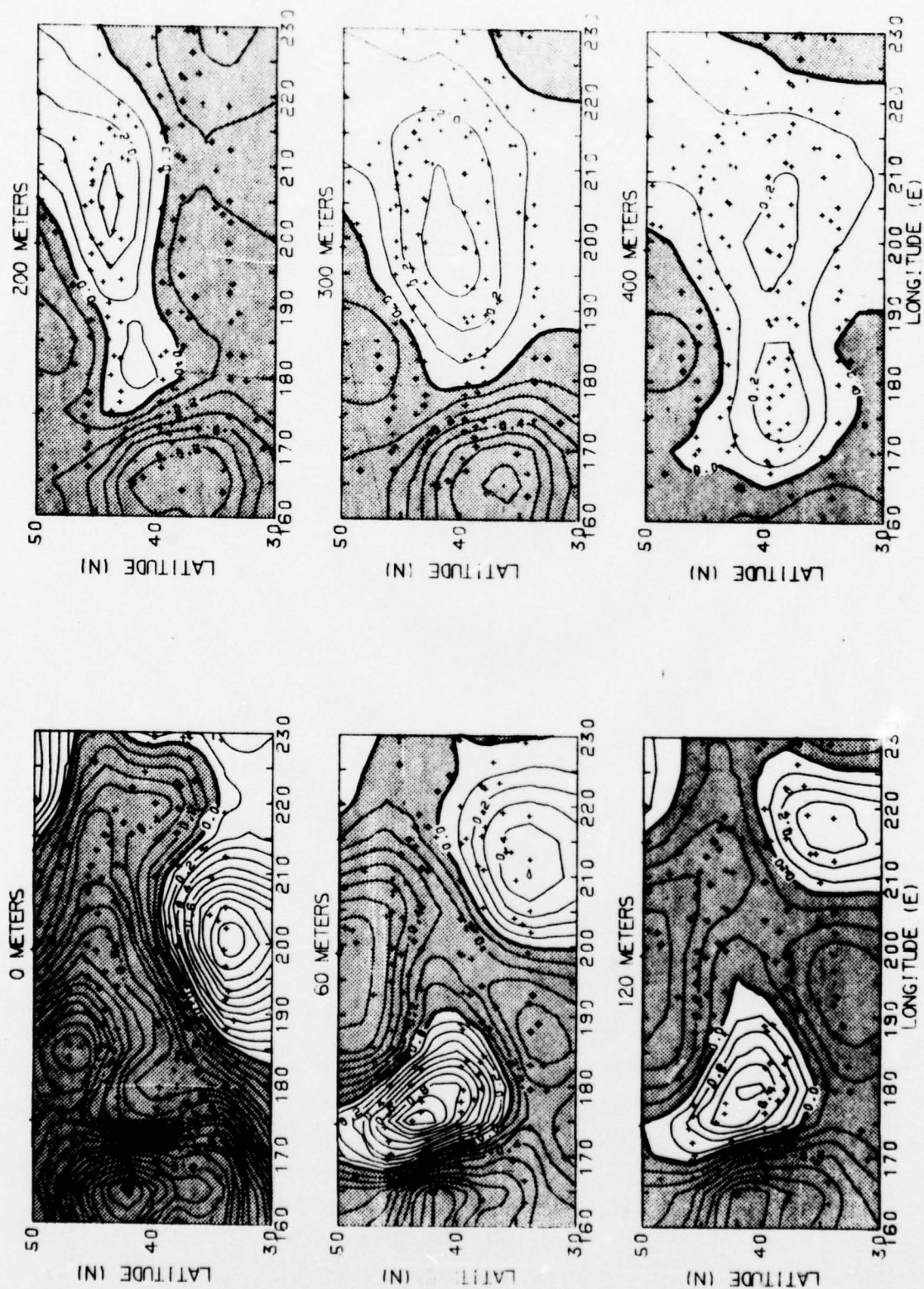


FIGURE 5. Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

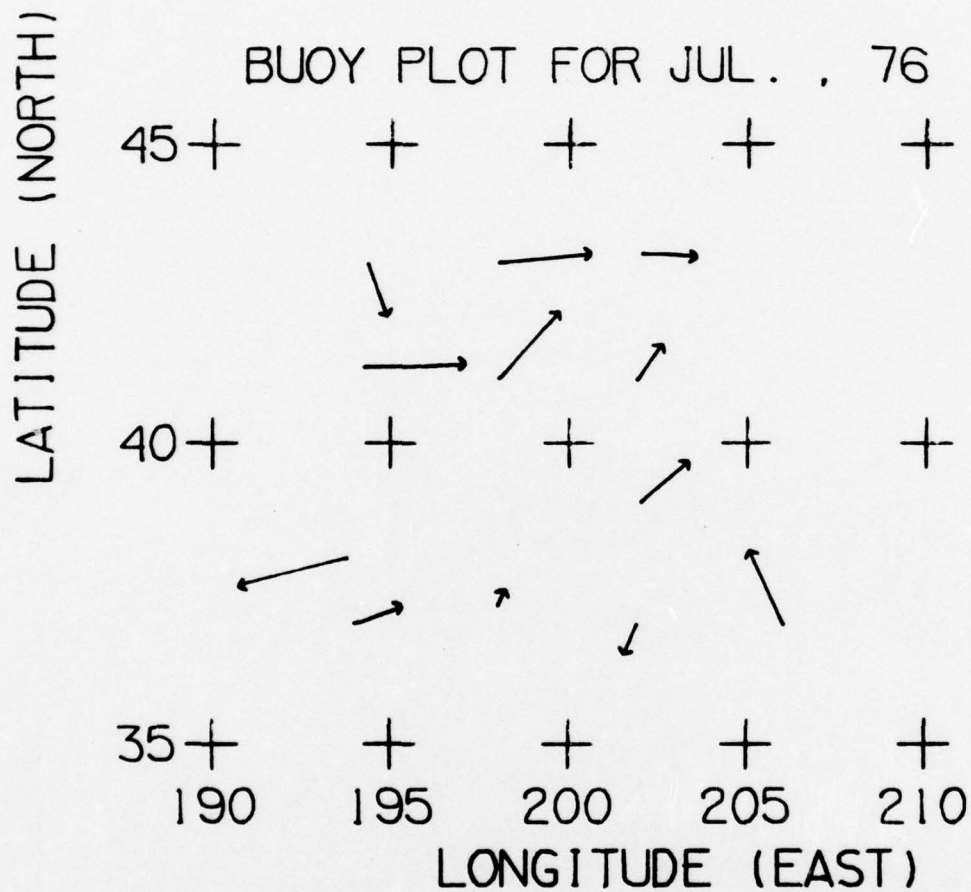


FIGURE 6.

Monthly buoy displacement vectors. Vectors are drawn from start point at beginning of month to terminal point at end of month.

WIND SPEED (M/SEC)

AUG 76

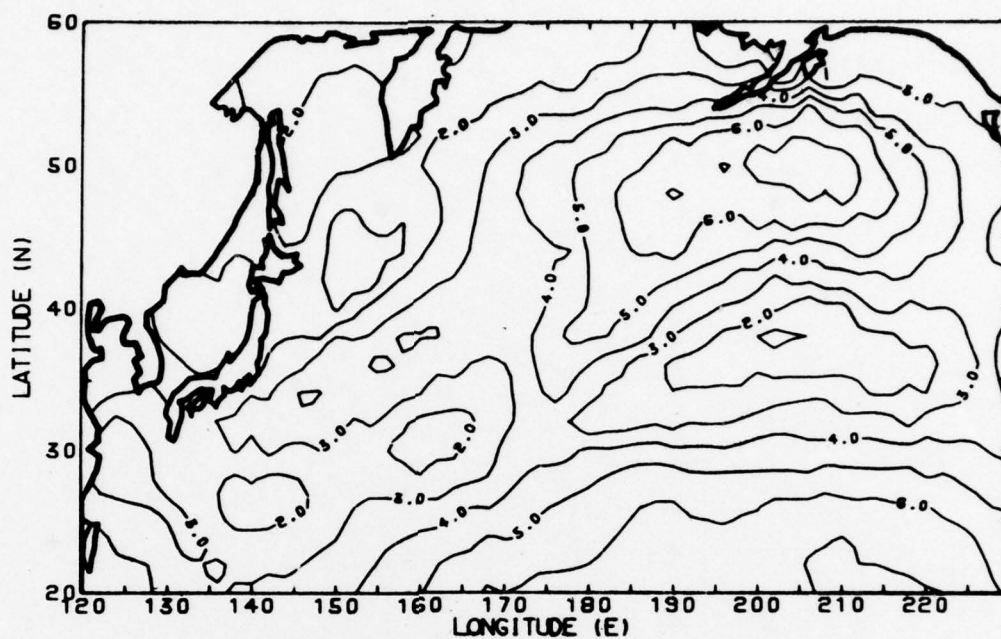


FIGURE 7.1 Absolute value of monthly mean vector wind velocities at 19.5 meters. Contour intervals are 1 m/sec.

WIND DIRECTION

AUG 76

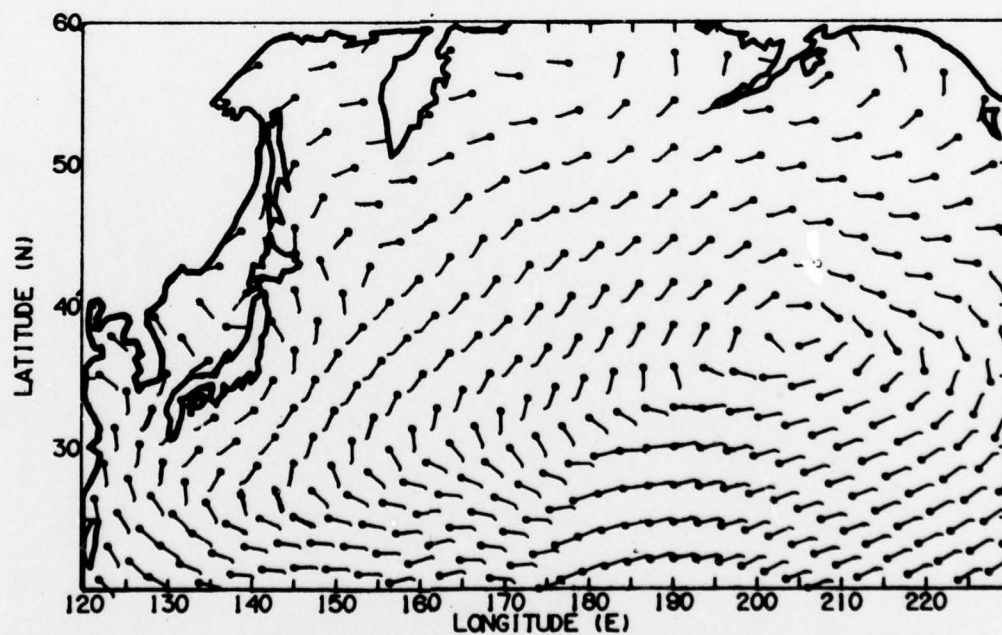


FIGURE 7.2 Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vanes on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

WIND STRESS (DYNES/CM²)

AUG 76

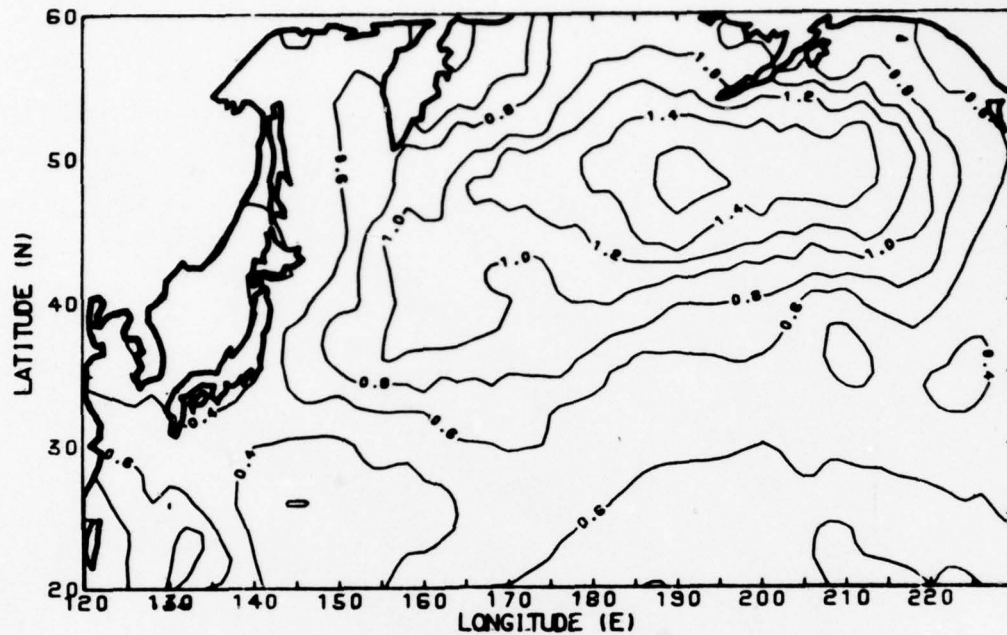


FIGURE 7.3 Monthly mean wind stress is the mean of 6-hourly wind stress at 10 meters calculated from FNWC wind data. Contour intervals are 0.2 dynes/cm².

CURL OF WIND STRESS (10⁻⁹ DYNES/CM³)

AUG 76

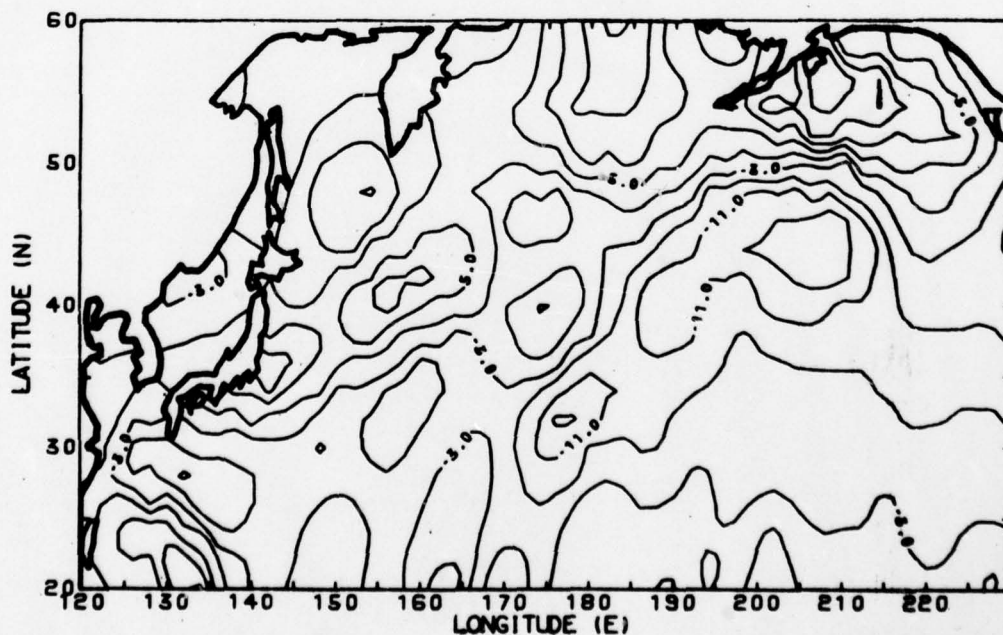


FIGURE 7.4 The vertical component of monthly mean wind stress curl is the mean of 6-hourly wind stress curl approximated by finite-differences from 6-hourly wind stresses at 10 meters. Isolines of zero curl are plotted heavily, and contour intervals are 4.0×10^{-9} dynes/cm³.

U STAR CUBED ((M/SEC)**3)

AUG 76

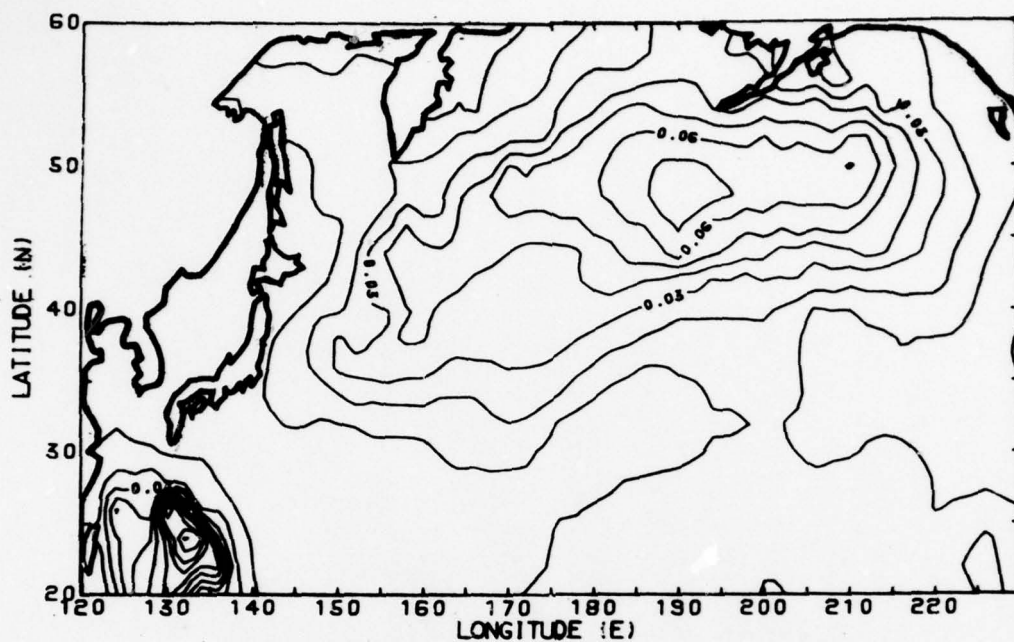


FIGURE 7.5

Monthly mean wind shear stress velocity cubed, U_*^3 is the mean of 6-hourly wind shear stress velocity cubed calculated from wind speed at 10 meters. Contour intervals are 0.01 (m/sec)^3 .

SEA SURFACE TEMPERATURE (DEG.C)

AUG 76

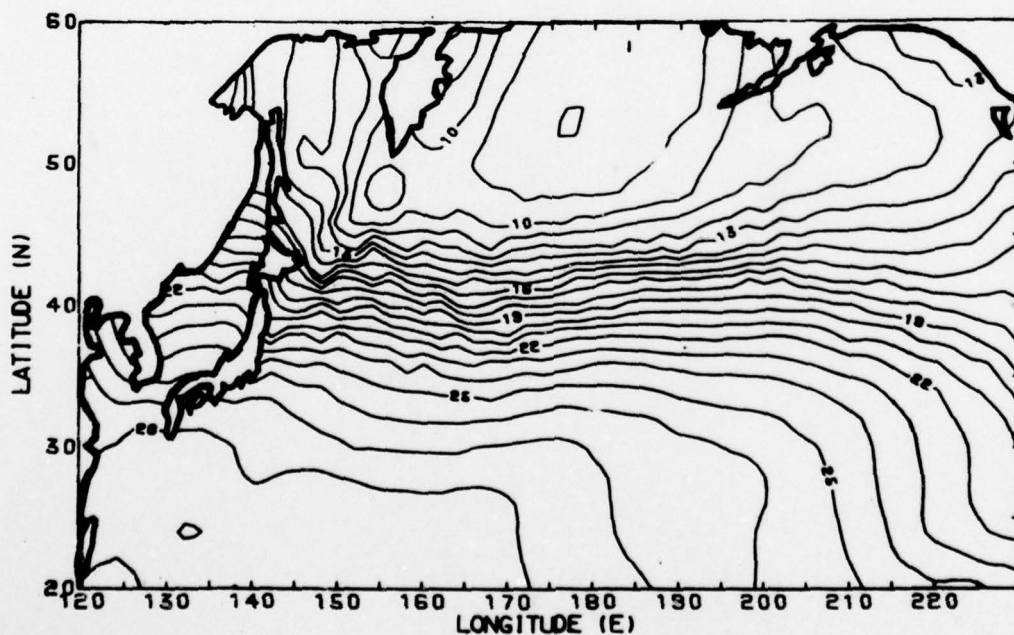


FIGURE 7.6

Monthly mean sea surface temperature is the mean of 12-hourly FNWC sea surface temperatures. Contour intervals are 1°C .

AIR TEMPERATURE (DEG. C) AUG 76

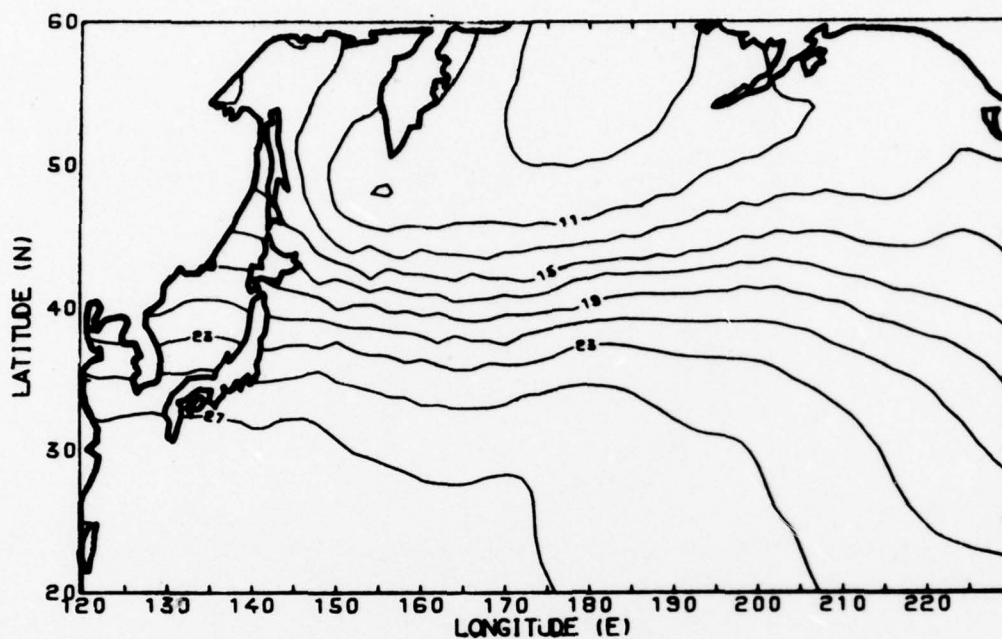


FIGURE 7.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) AUG 76

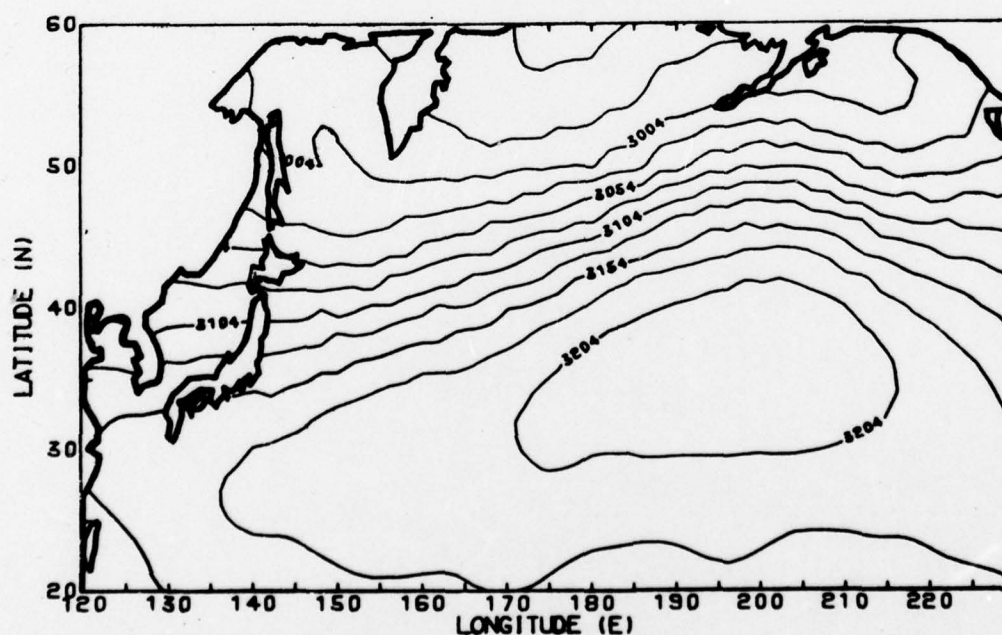


FIGURE 7.8 Monthly mean 700 mb height is the mean of 12-hourly FNWC 700 mb heights. Contour intervals are 25 meters.

VAPOR PRESSURE (MB) AUG 76

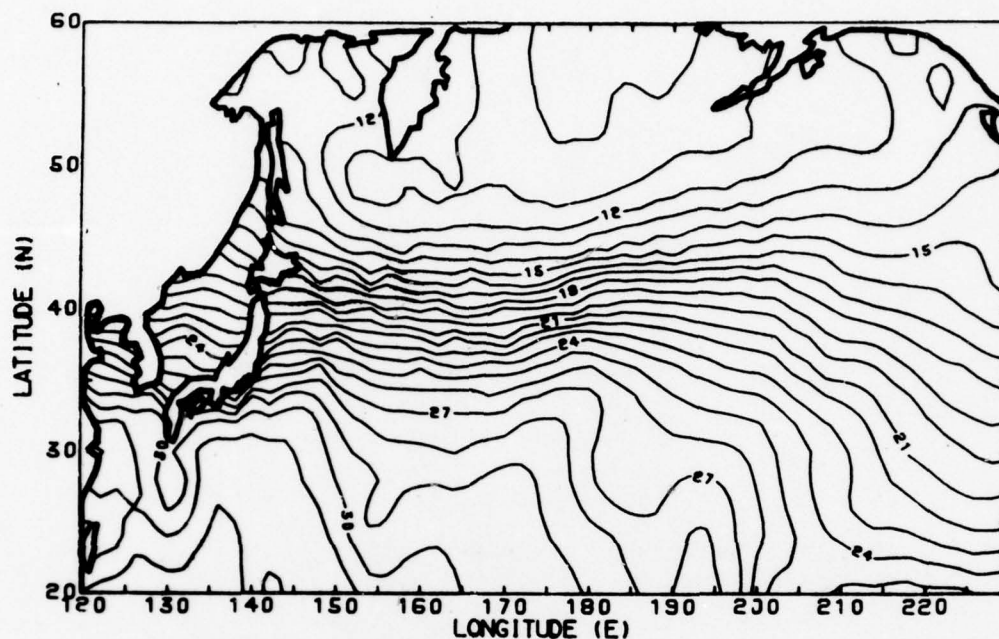


FIGURE 7.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM² SEC) AUG 76

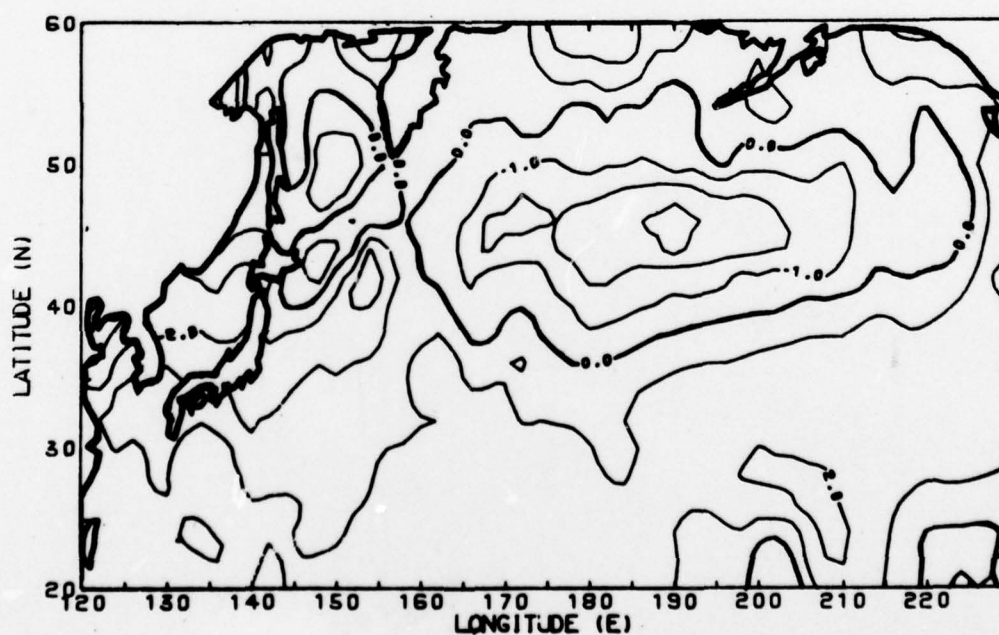


FIGURE 7.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm² sec.

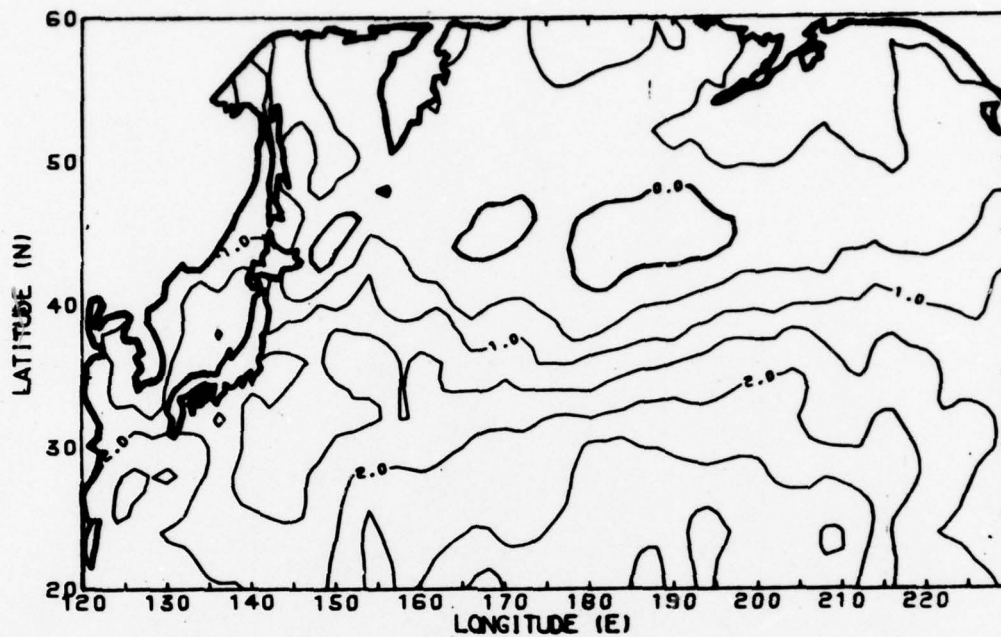


FIGURE 7.11

Monthly mean latent heat flux (ocean to atmosphere) is the mean of 12-hourly latent heat flux calculated from FNWC sea temperature, vapor pressure and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 0.5×10^{-3} cal/cm 2 sec.

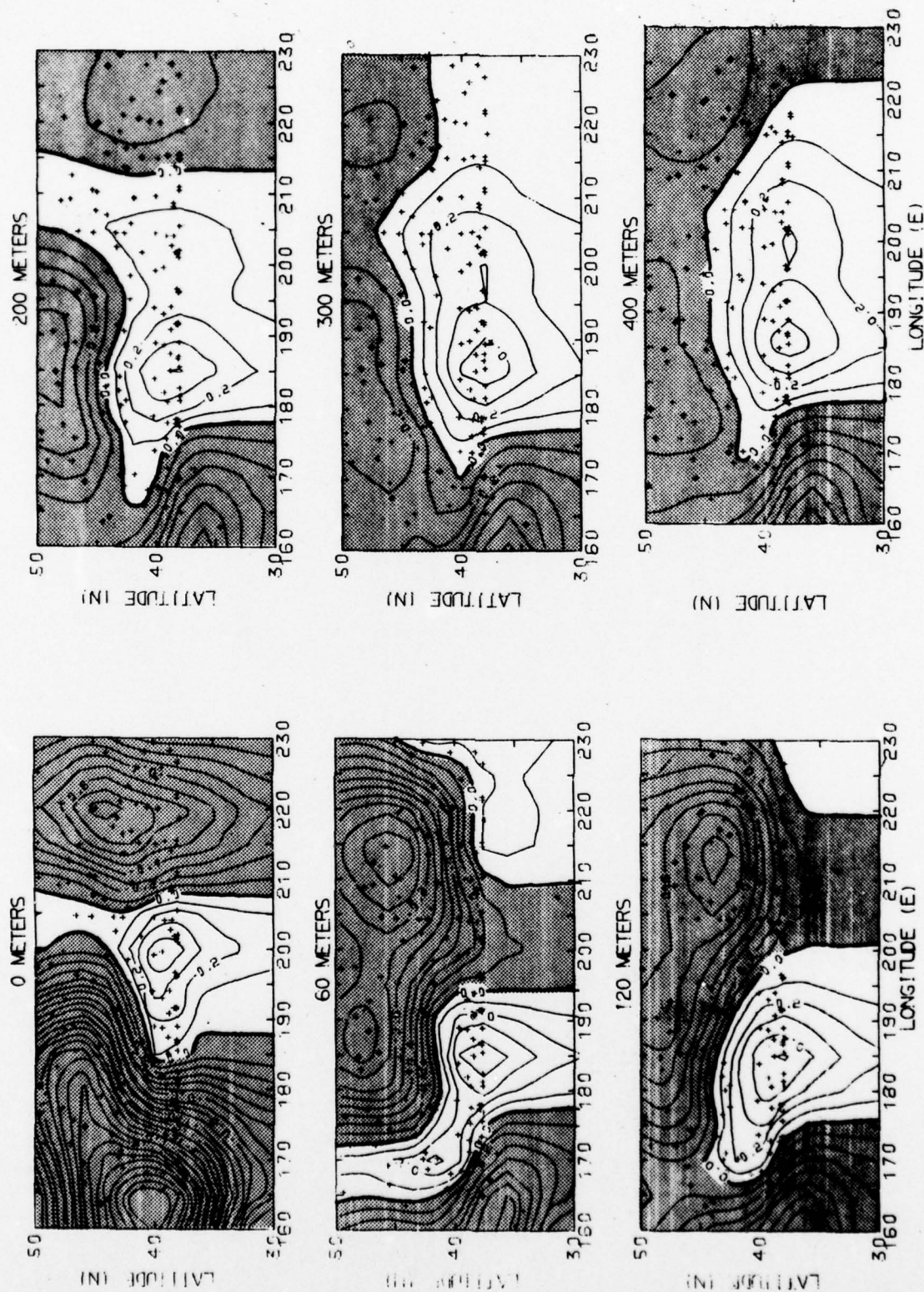


FIGURE 8. Monthly temperature anomalies (°C) contoured at fixed depths. Negative anomaly areas are hatchured and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

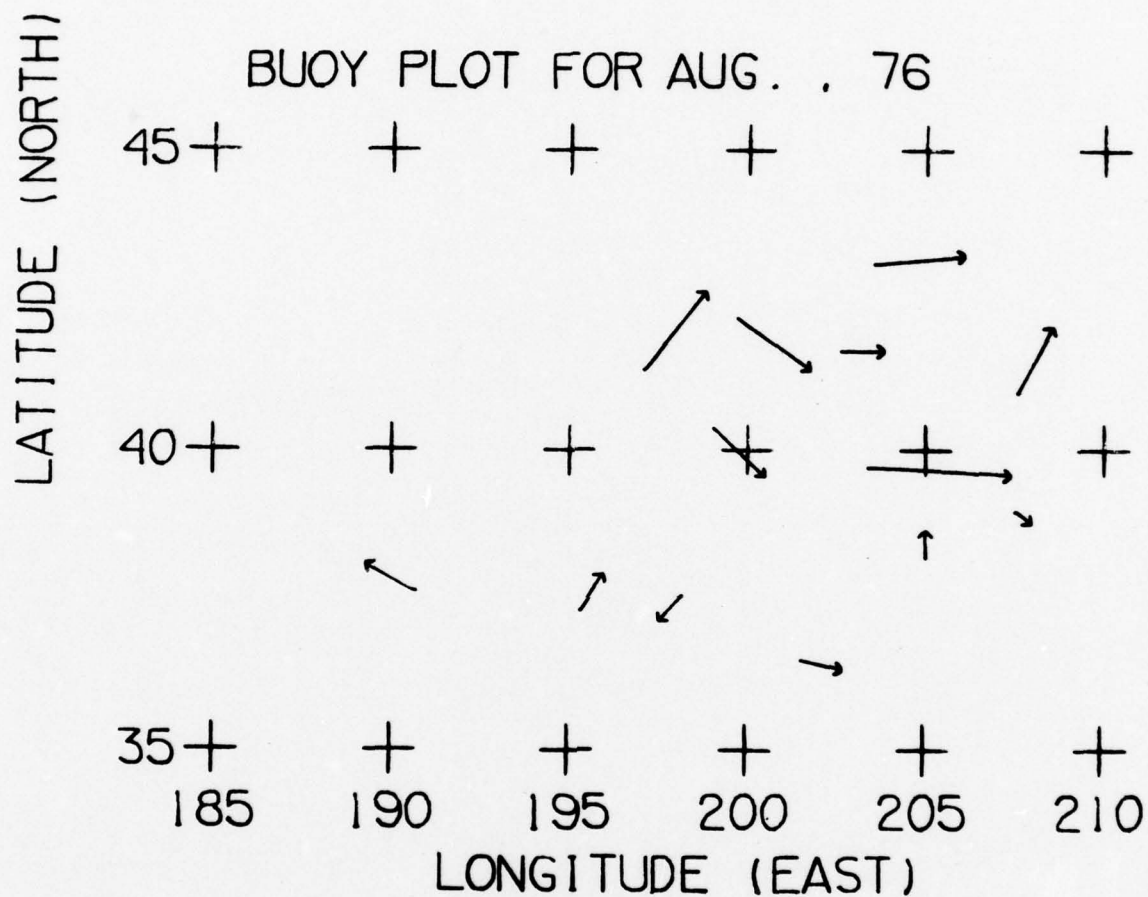


FIGURE 9.

Monthly buoy displacement vectors. Vectors are drawn from start point at beginning of month to terminal point at end of month.

WIND SPEED (M/SEC)

SEP 76

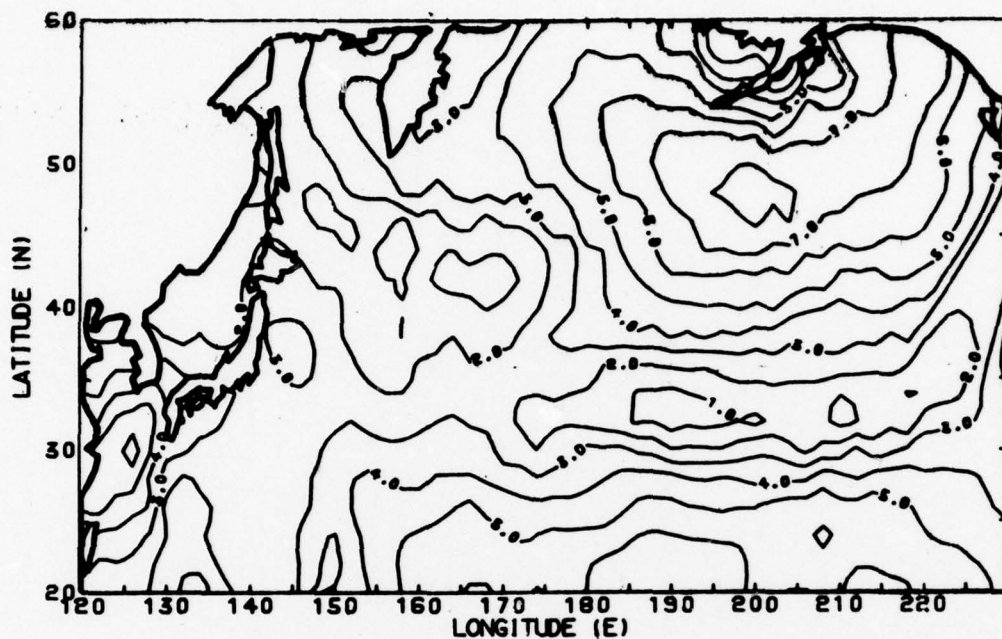


FIGURE 10.1 Absolute value of monthly mean vector wind velocities at 19.5 meters. Contour intervals are 1 m/sec.

WIND DIRECTION

SEP 76

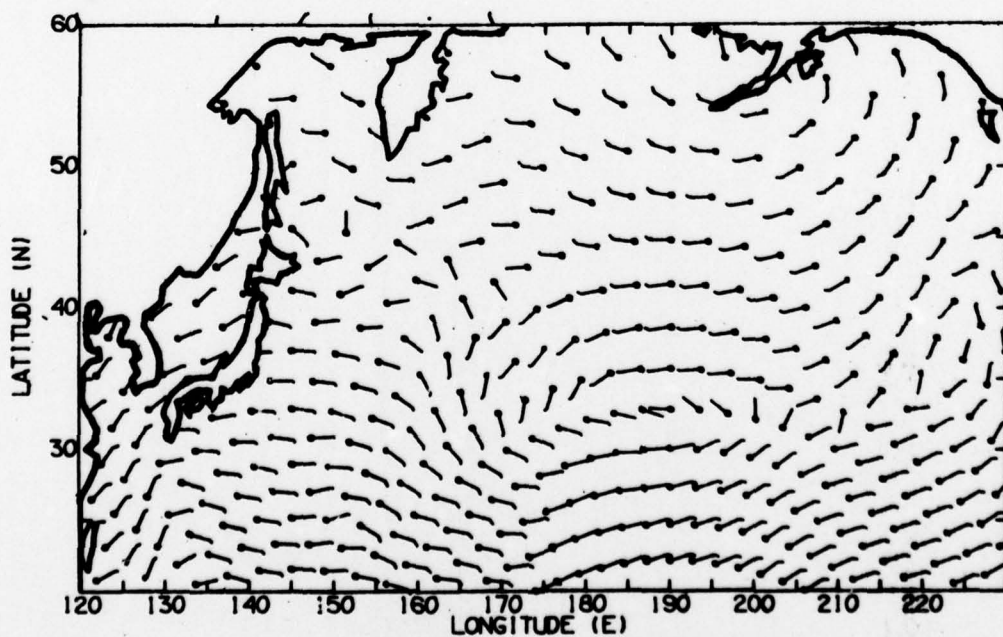


FIGURE 10.2 Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vanes on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

WIND STRESS (DYNES/CM²)

SEP 76

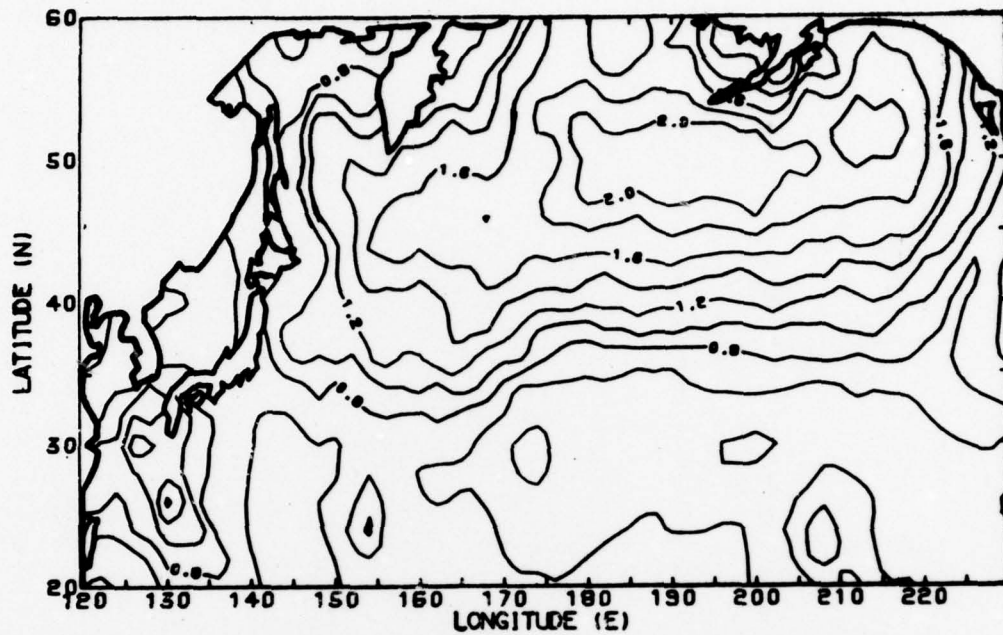


FIGURE 10.3 Monthly mean wind stress is the mean of 6-hourly wind stress at 10 meters calculated from FNWC wind data. Contour intervals are 0.2 dynes/cm².

CURL OF WIND STRESS (10⁻⁹ DYNES/CM³)

SEP 76

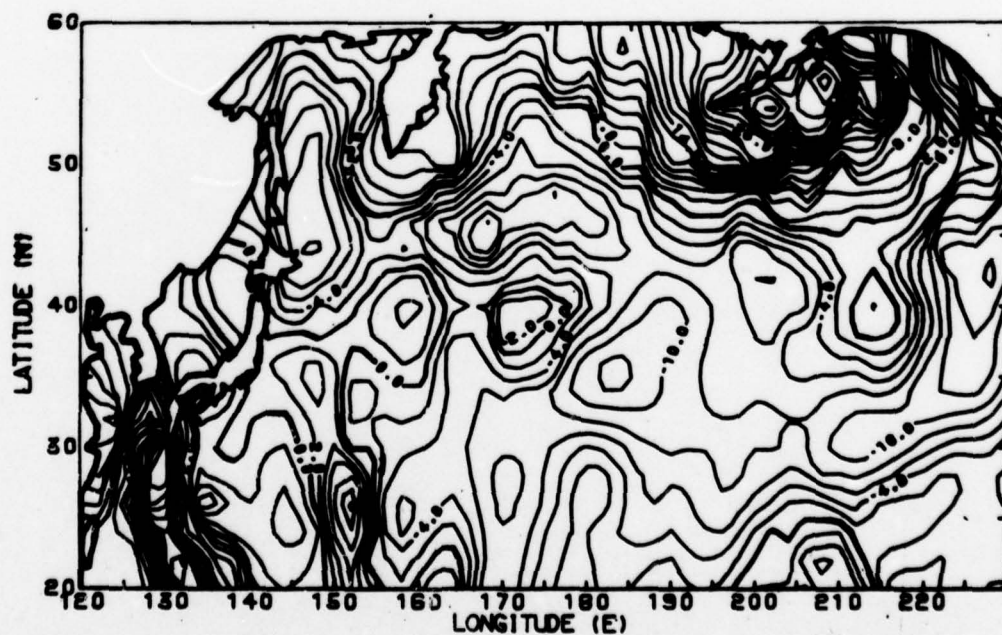
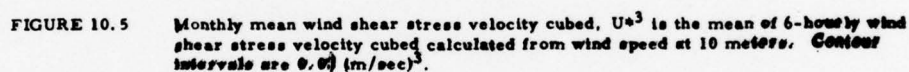
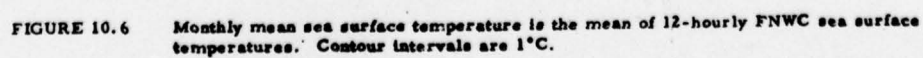


FIGURE 10.4 The vertical component of monthly mean wind stress curl is the mean of 6-hourly wind stress curl approximated by finite-differences from 6-hourly wind stresses at 10 meters. Isolines of zero curl are plotted hourly, and contour intervals are 4.0×10^{-9} dynes/cm³.

SEP 76



SEP 76



AIR TEMPERATURE (DEG. C) SEP 76

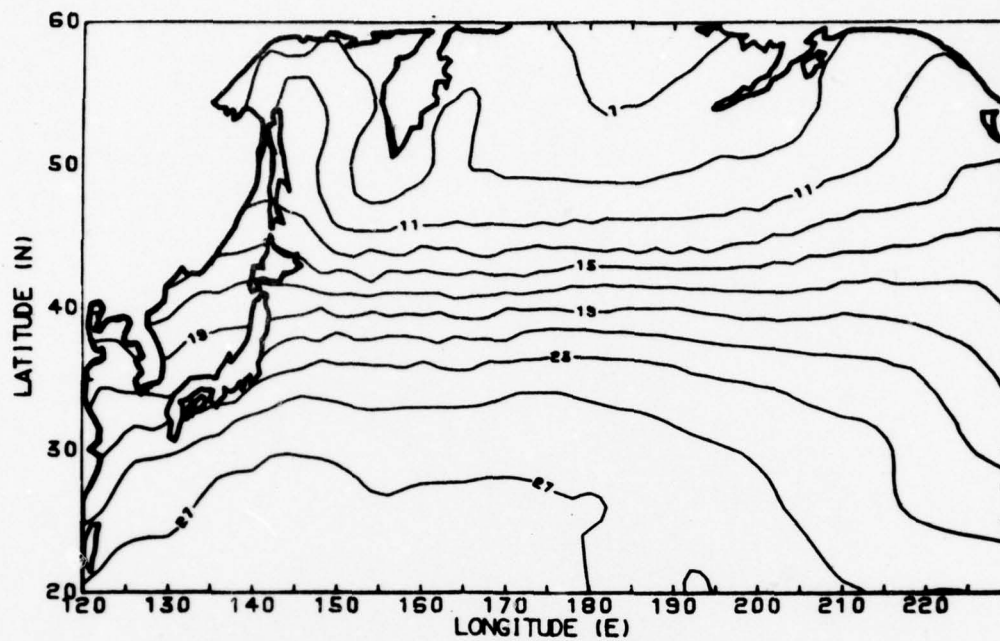


FIGURE 10.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) SEP 76

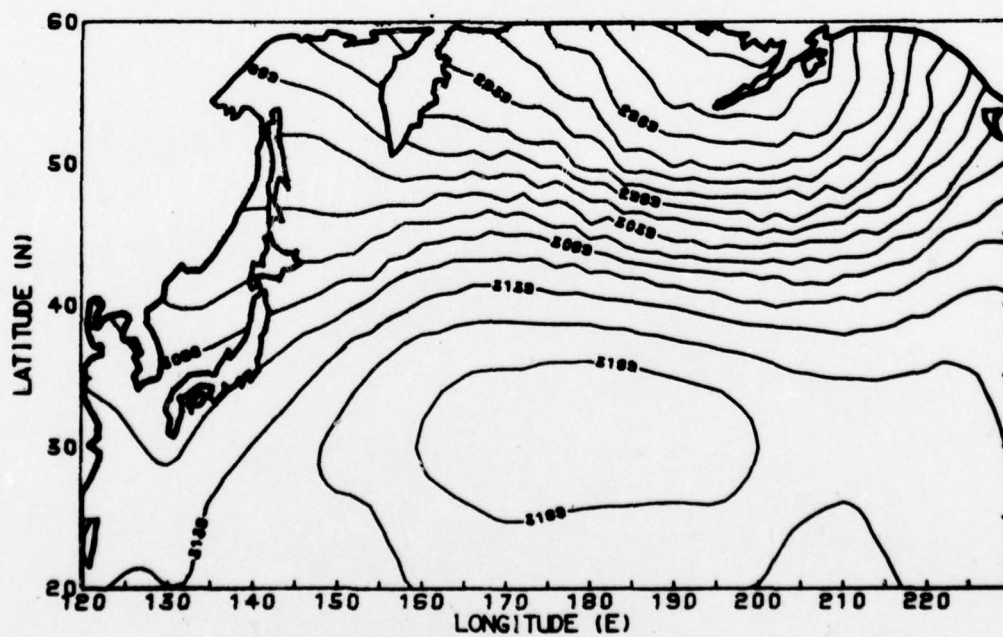


FIGURE 10.8 Monthly mean 700 mb height is the mean of 12-hourly FNWC 700 mb heights. Contour intervals are 25 meters.

VAPOR PRESSURE (MB) SEP 76

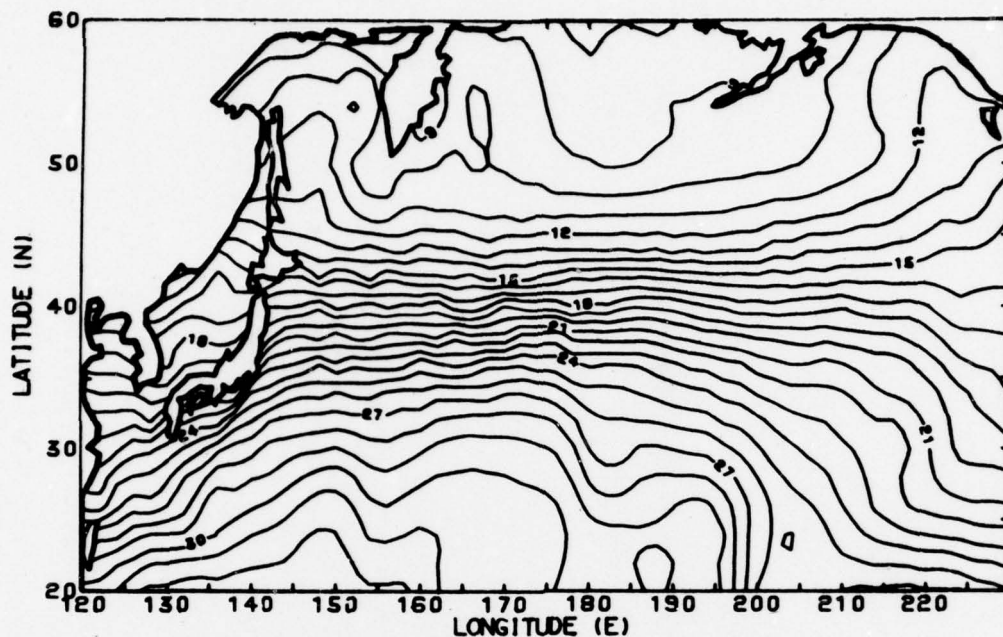


FIGURE 10.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM 2 SEC) SEP 76

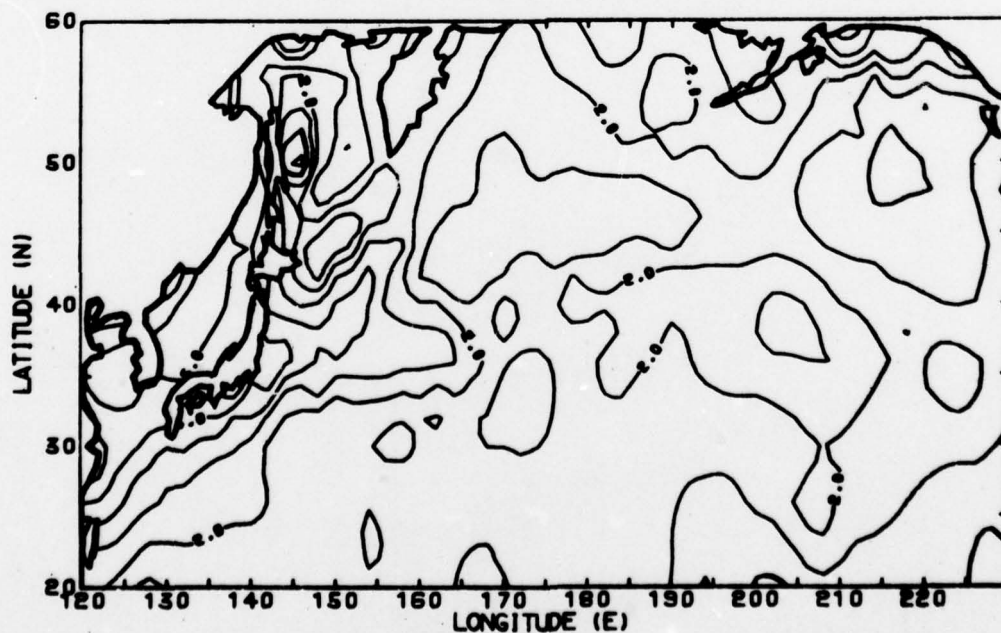
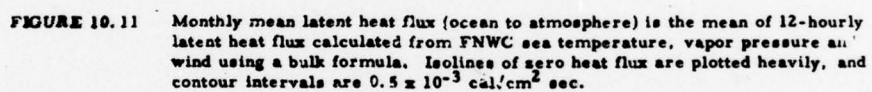


FIGURE 10.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm 2 sec.



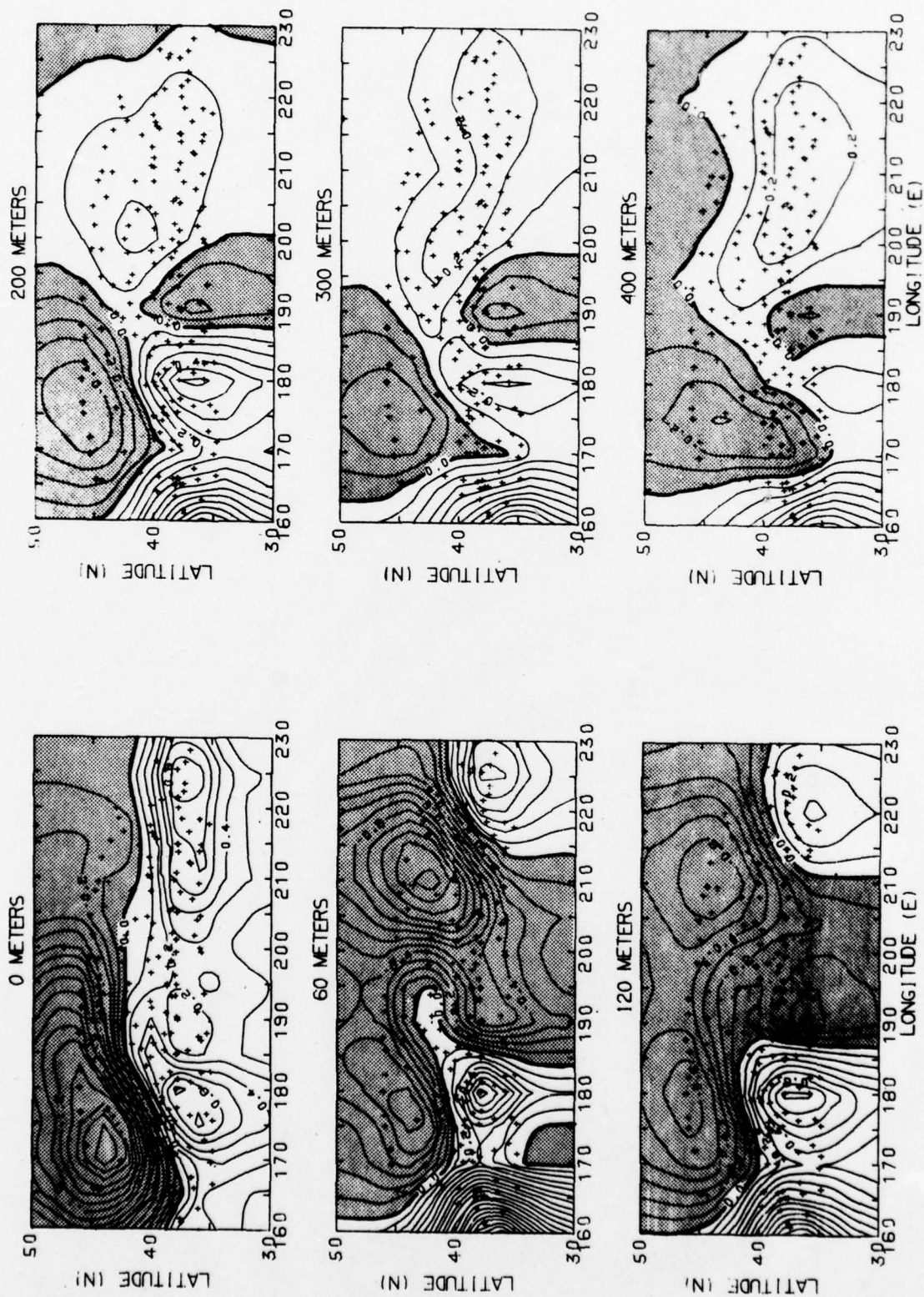


FIGURE 11. Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

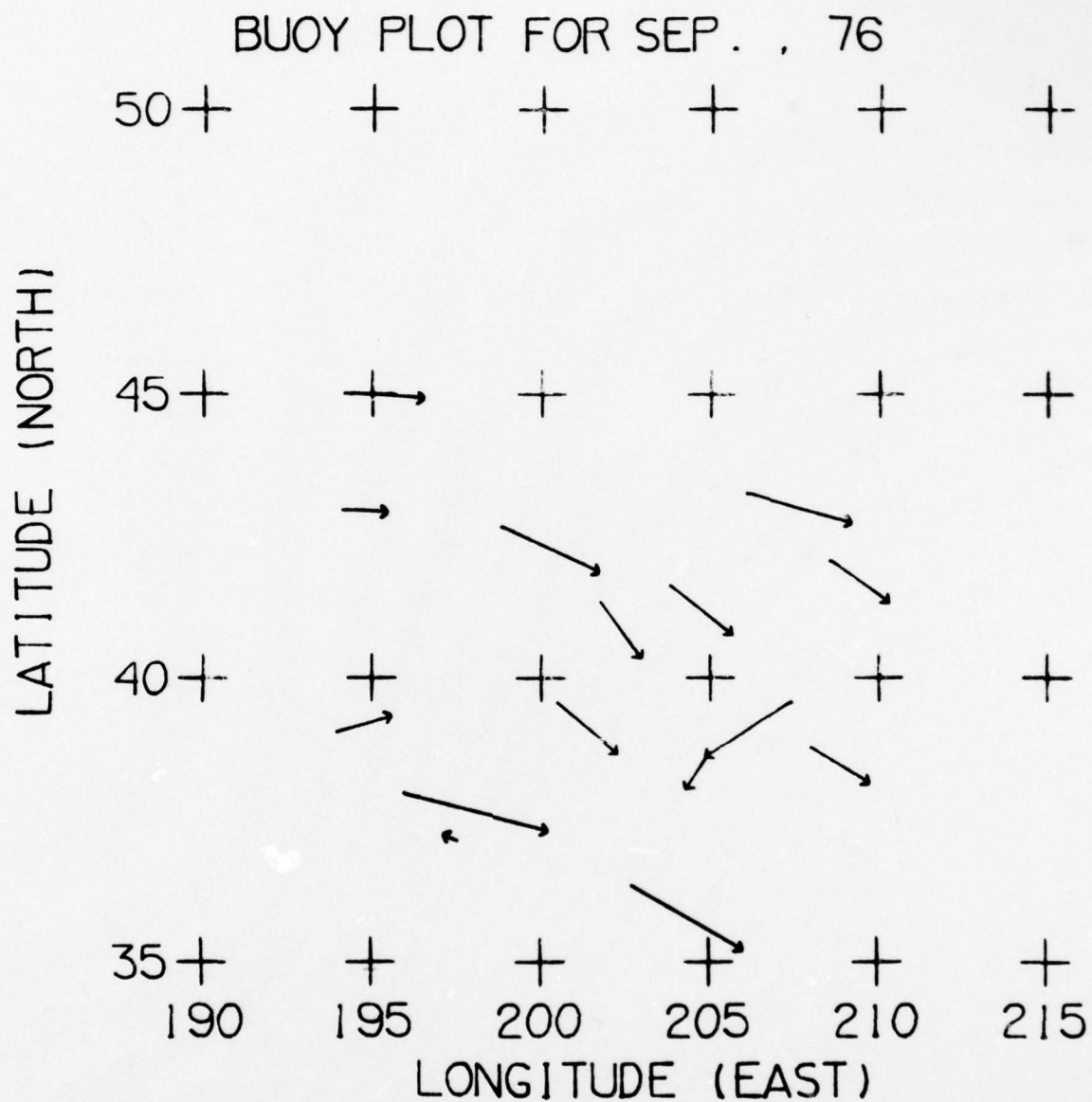


FIGURE 12.

Monthly buoy displacement vectors. Vectors are drawn from start point at beginning of month to terminal point at end of month.

WIND SPEED (M/SEC)

OCT 76

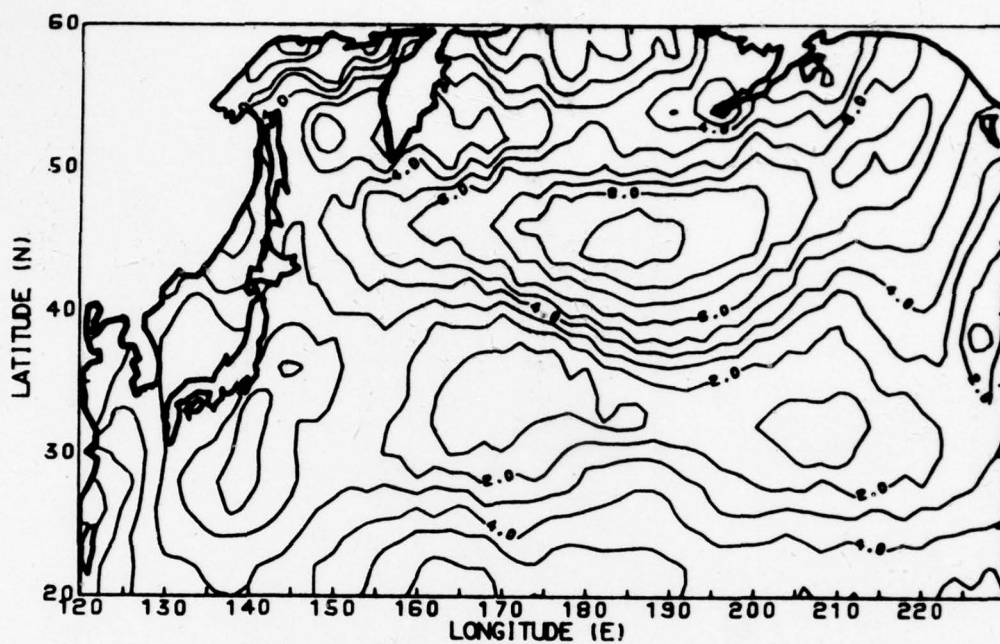


FIGURE 13.1 Absolute value of monthly mean vector wind velocities at 19.5 meters. Contour intervals are 1 m/sec.

WIND DIRECTION

OCT 76

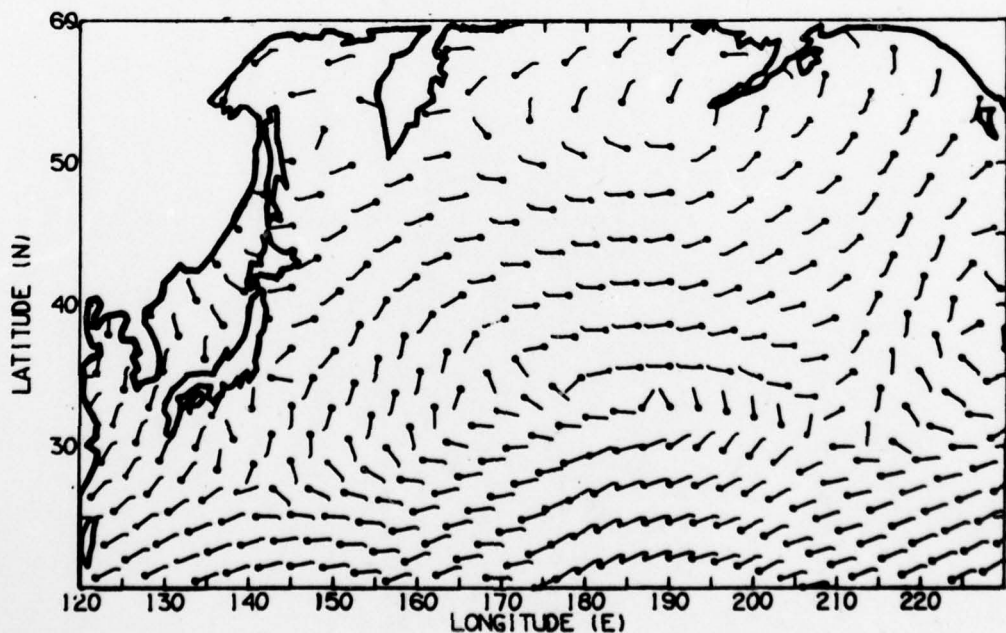


FIGURE 13.2 Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vanes on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

WIND STRESS (DYNES/CM²)

OCT 76

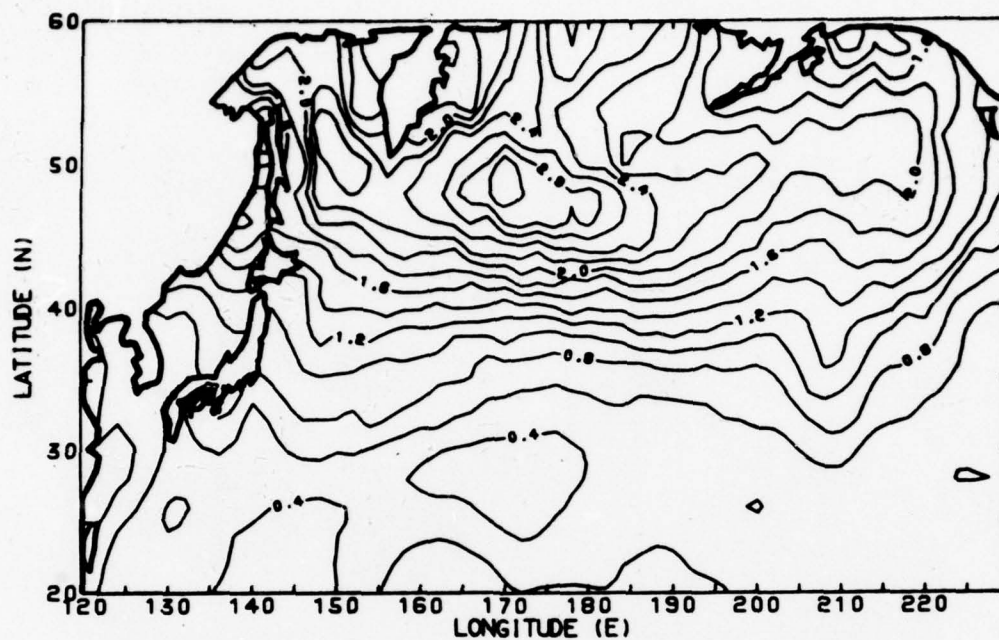


FIGURE 13.3 Monthly mean wind stress is the mean of 6-hourly wind stress at 10 meters calculated from FNWC wind data. Contour intervals are 0.2 dynes/cm².

CURL OF WIND STRESS (10^{-9} DYNES/CM³)

OCT 76

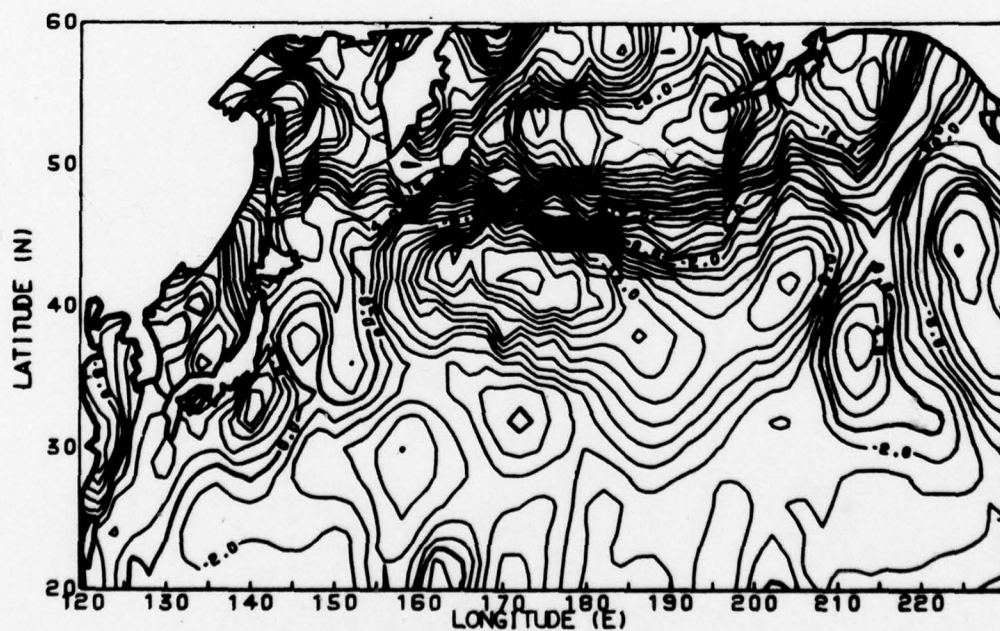
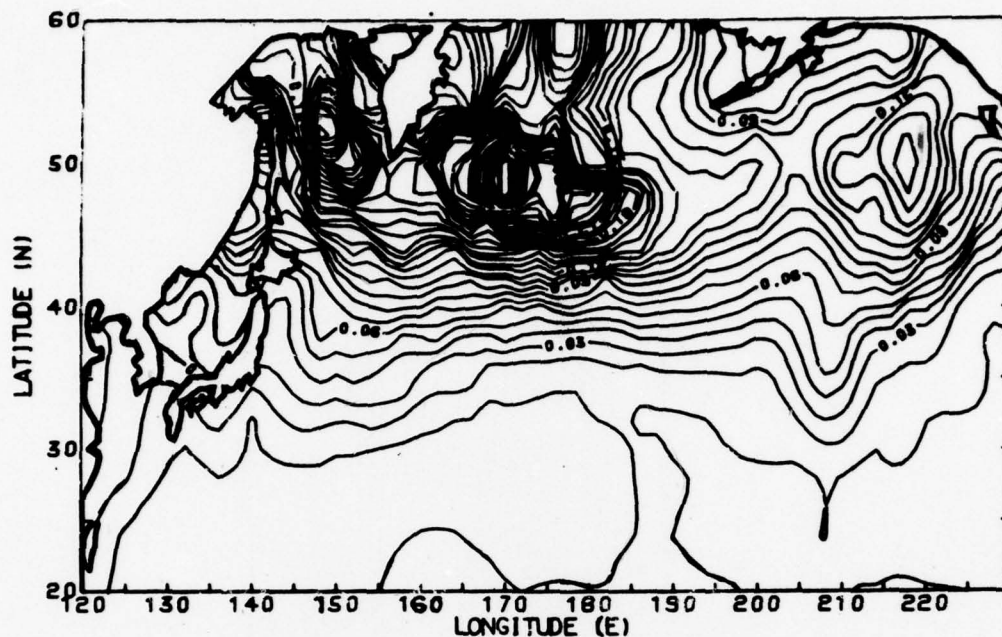


FIGURE 13.4 The vertical component of monthly mean wind stress curl is the mean of 6-hourly wind stress curl approximated by finite-differences from 6-hourly wind stresses at 10 meters. Isolines of zero curl are plotted heavily, and contour intervals are 4.0×10^{-9} dynes/cm³.

U STAR CUBED ((M/SEC)**3)

OCT 76



AIR TEMPERATURE (DEG. C) OCT 76

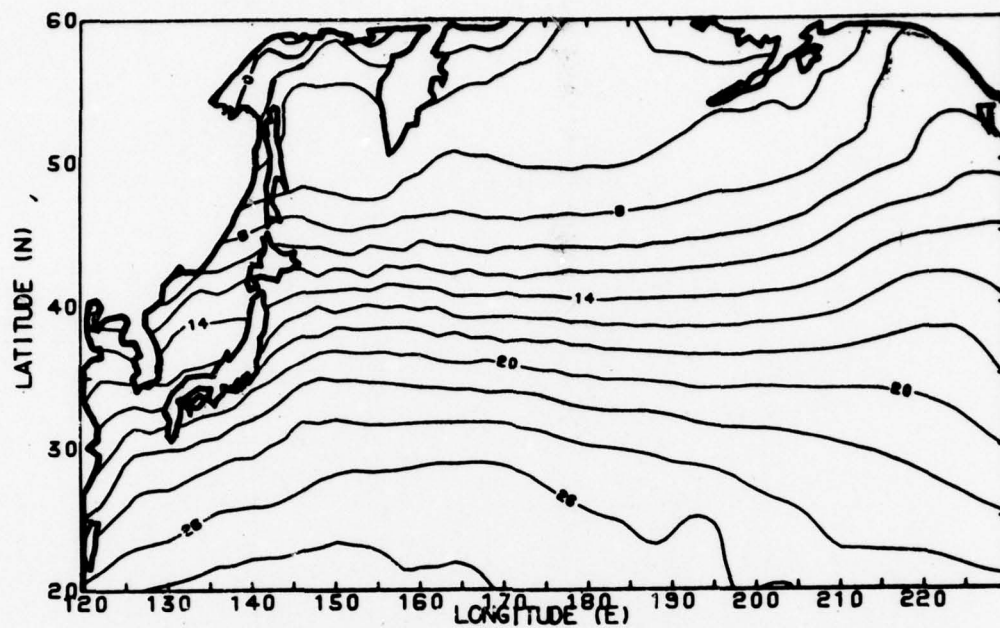


FIGURE 13.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) OCT 76

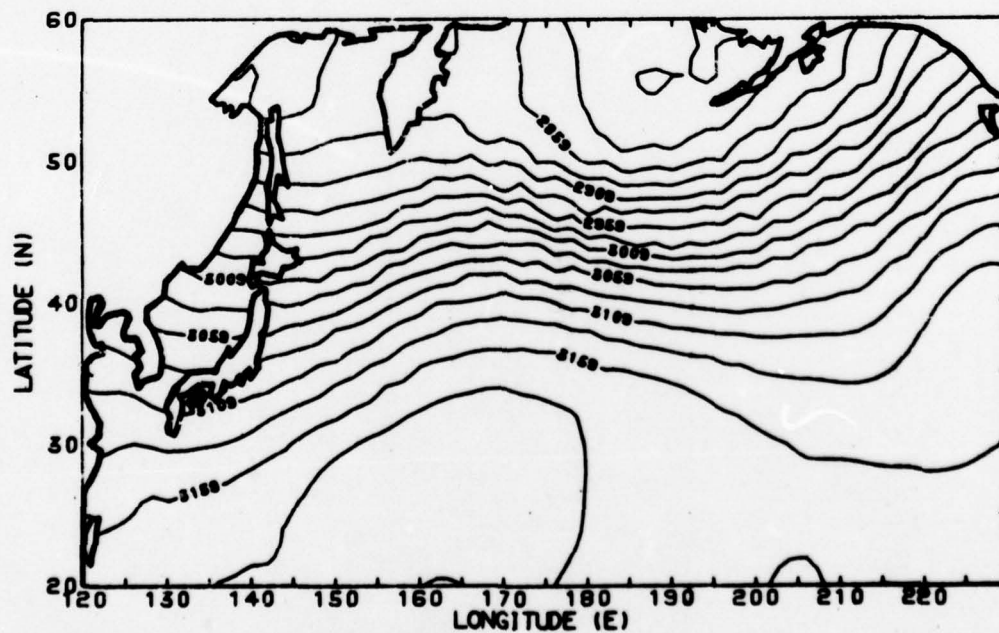


FIGURE 13.8 Monthly mean 700 mb height is the mean of 12-hourly FNWC 700 mb heights. Contour intervals are 25 meters.

VAPOR PRESSURE (MB) OCT 76

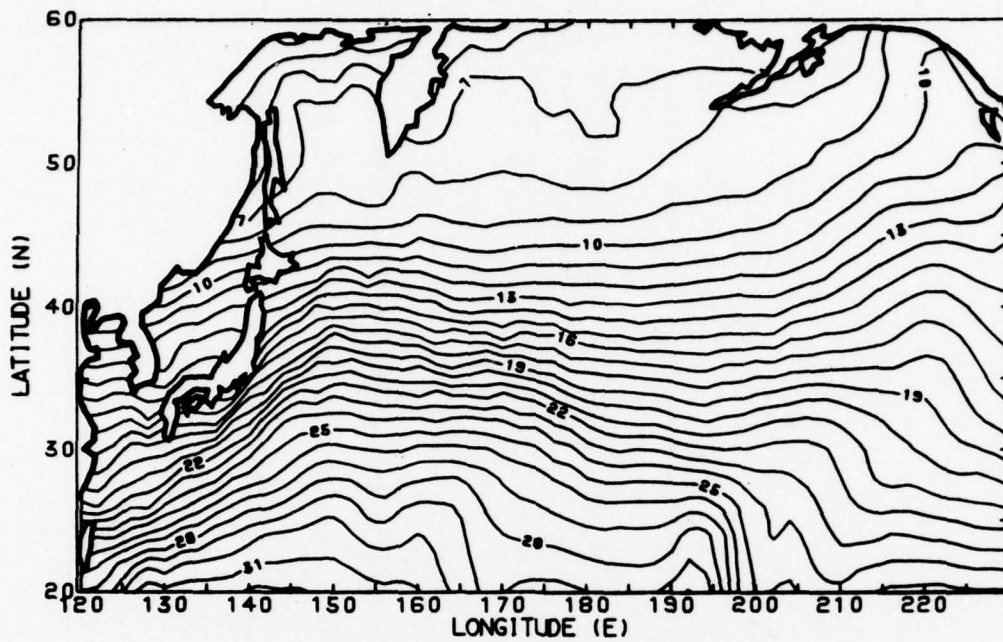


FIGURE 13.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM 2 SEC) OCT 76

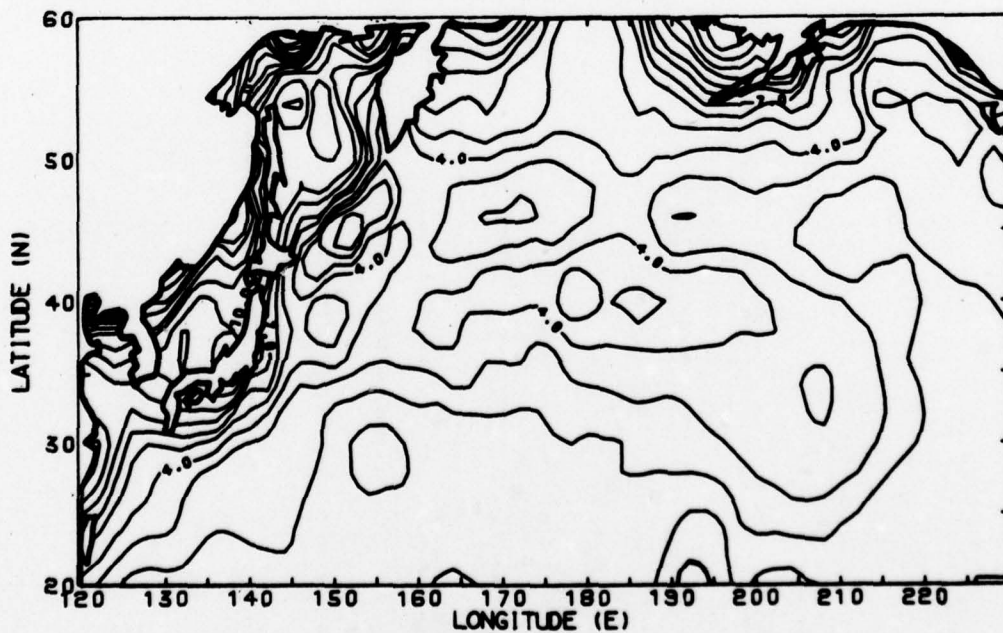
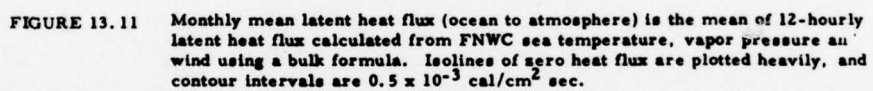


FIGURE 13.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm 2 sec.



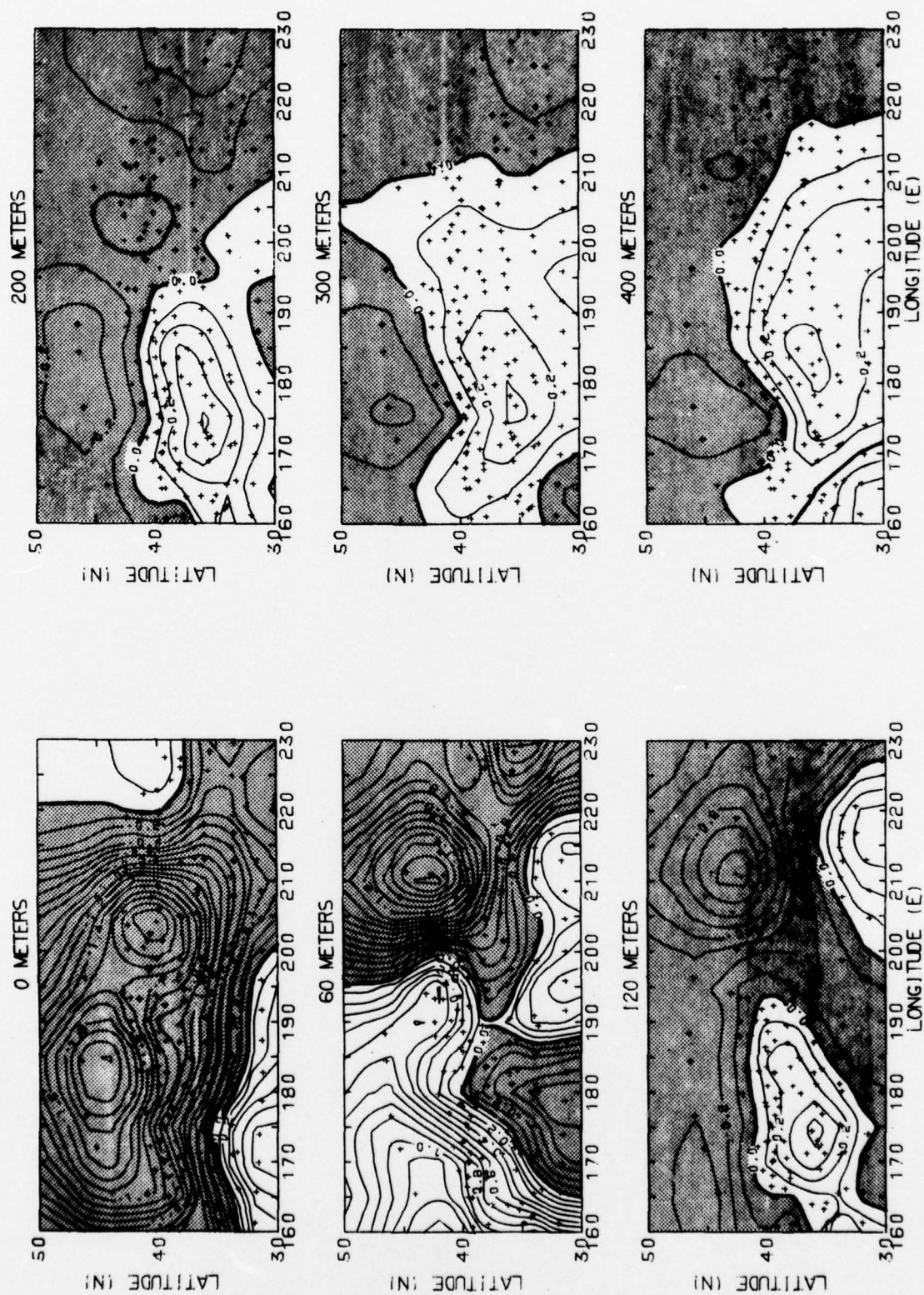


FIGURE 14. Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

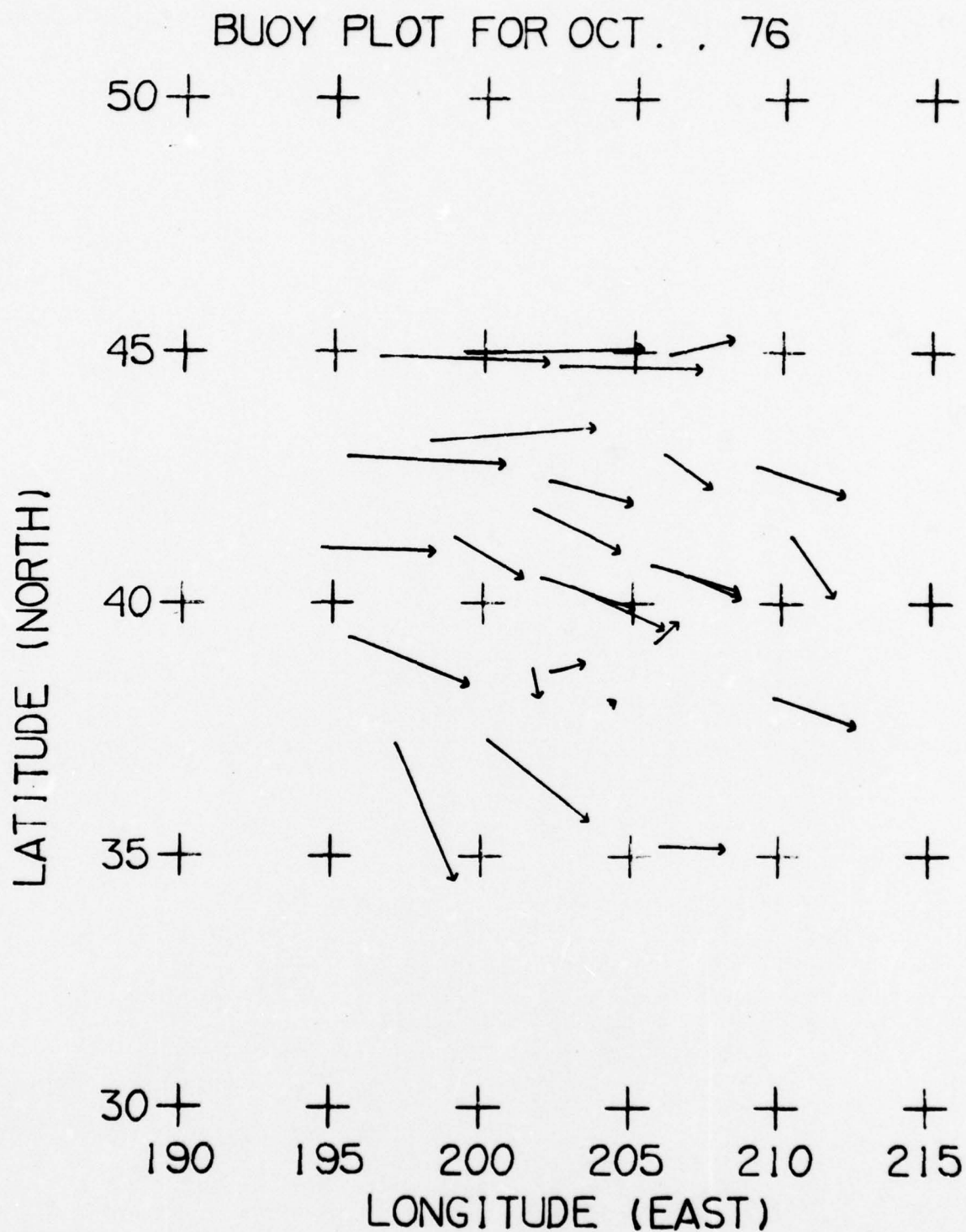


FIGURE 15.

Monthly buoy displacement vectors. Vectors are drawn from start point at beginning of month to terminal point at end of month.

WIND SPEED (M/SEC)

NOV 76

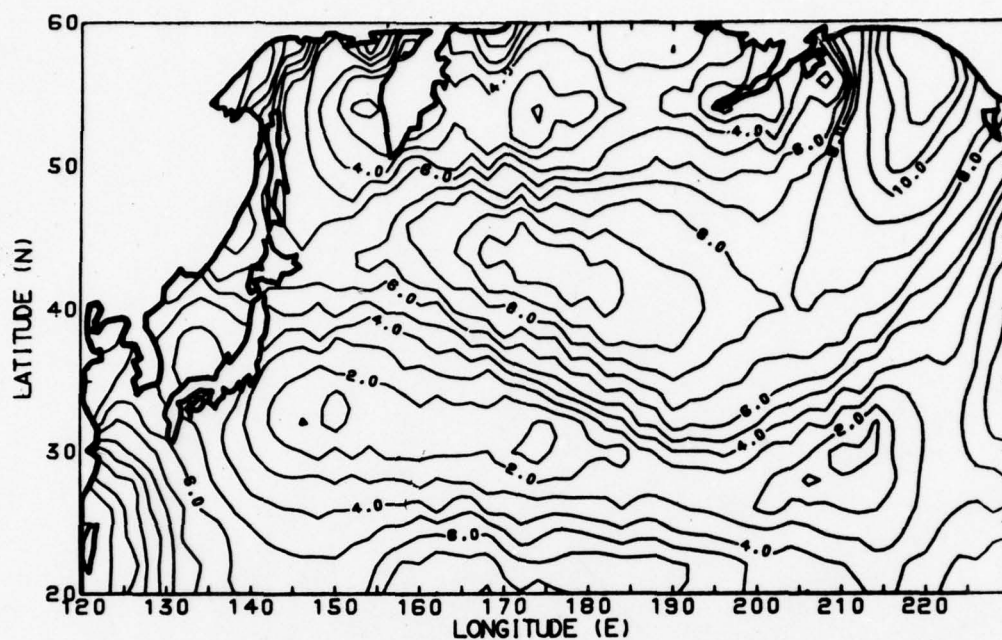


FIGURE 16.1 Absolute value of monthly mean vector wind velocities at 19.5 meters. Contour intervals are 1 m/sec.

WIND DIRECTION

NOV 76

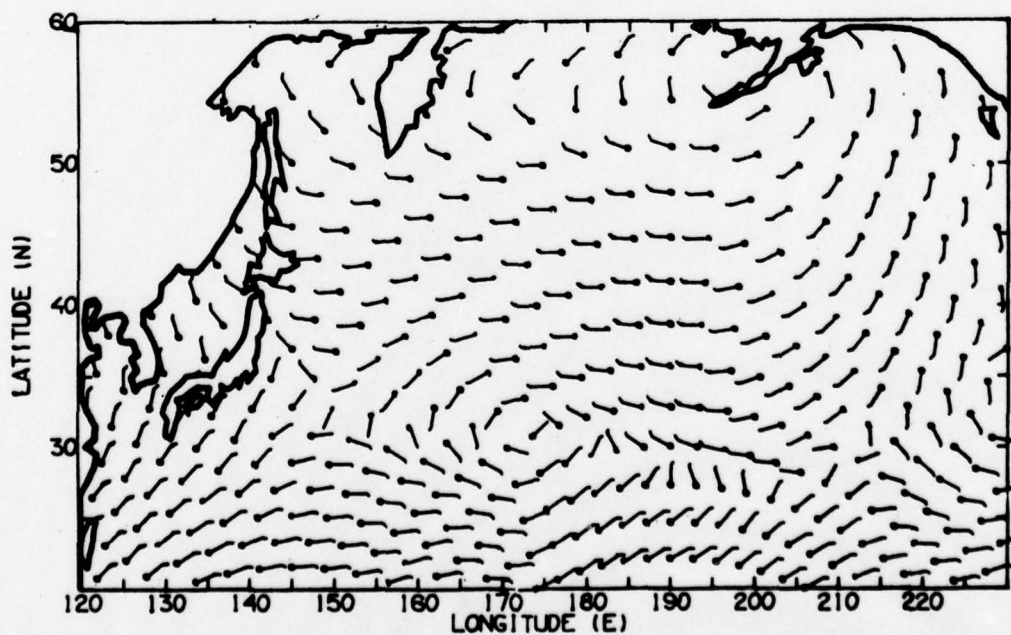
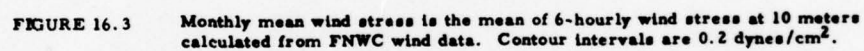
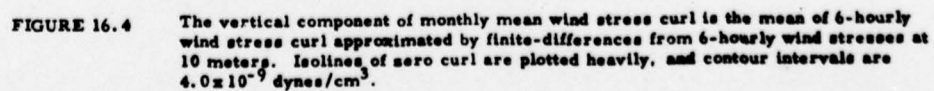


FIGURE 16.2 Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vanes on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

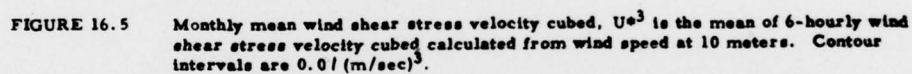
NOV 76



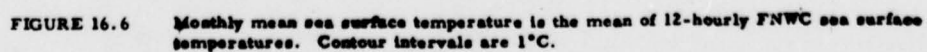
NOV '76



NOV 76



NOV 76



AIR TEMPERATURE (DEG. C) NOV 76

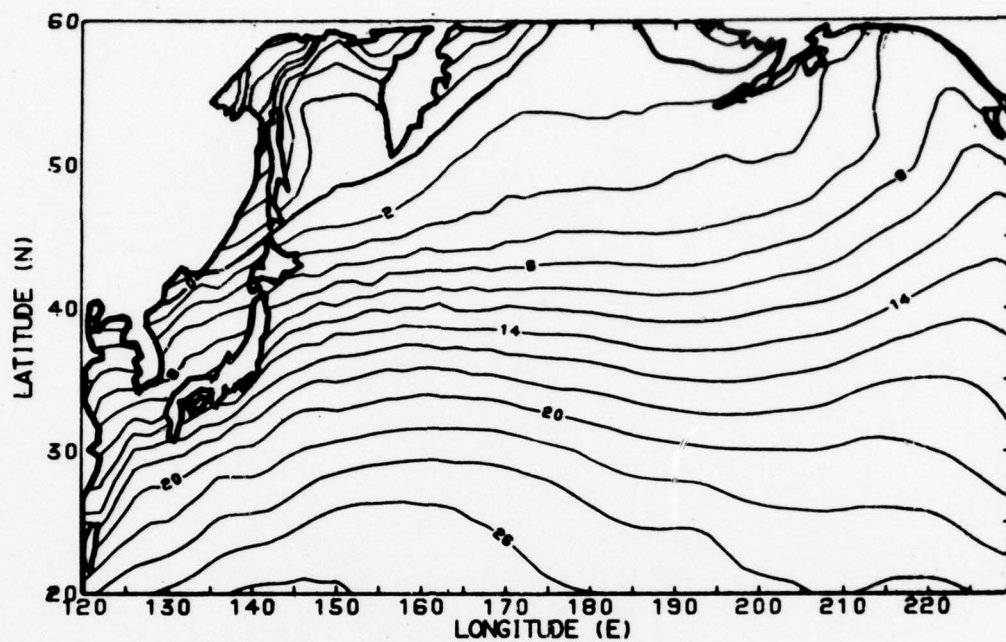


FIGURE 16.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) NOV 76

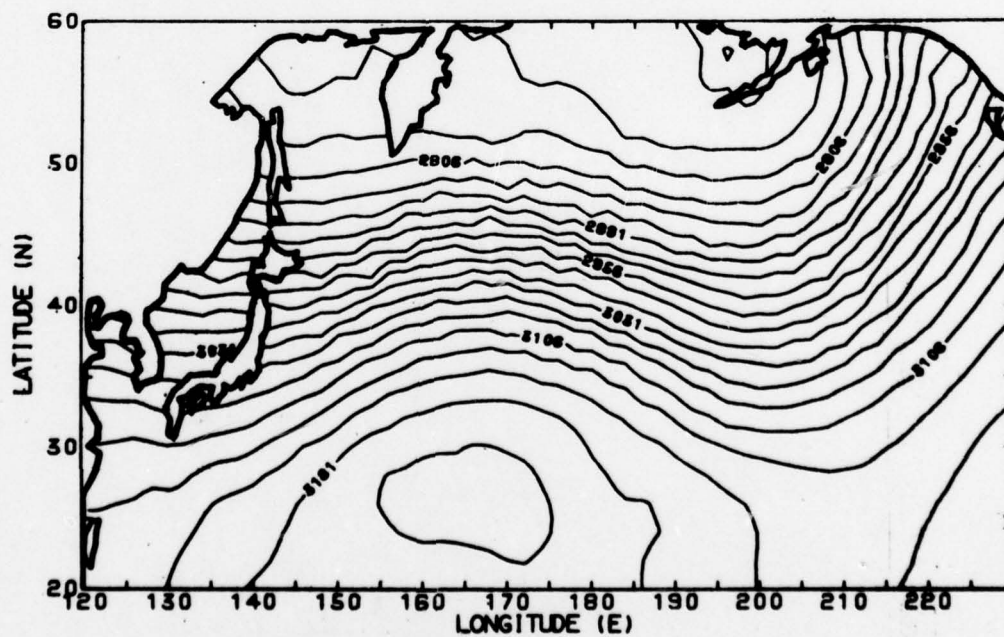


FIGURE 16.8 Monthly mean 700 mb height is the mean of 12-hourly FNWC 700 mb heights. Contour intervals are 25 meters.

VAPOR PRESSURE (MB) NOV 76

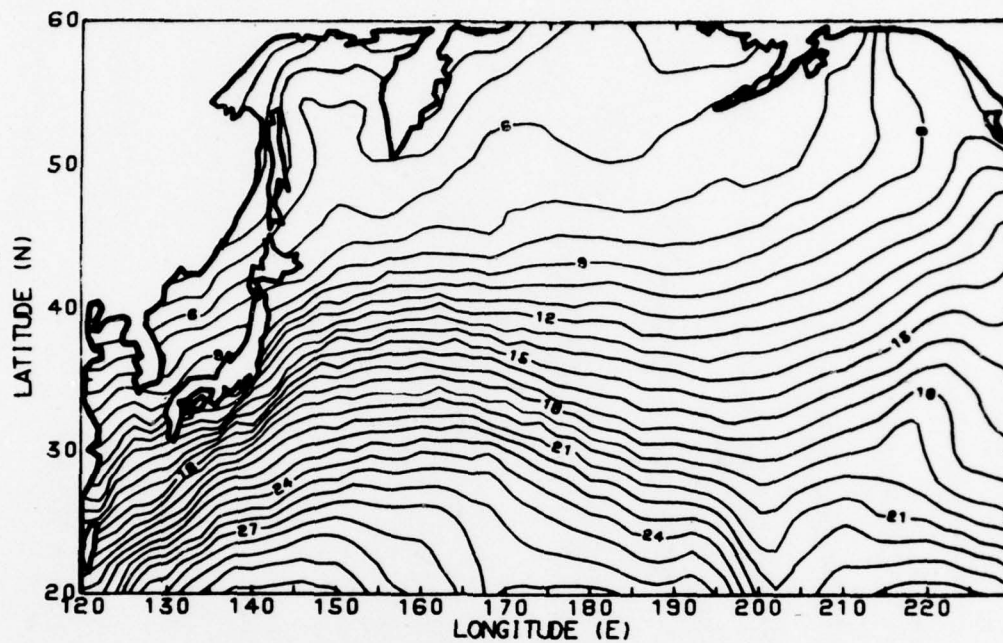


FIGURE 16.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM² SEC) NOV 76

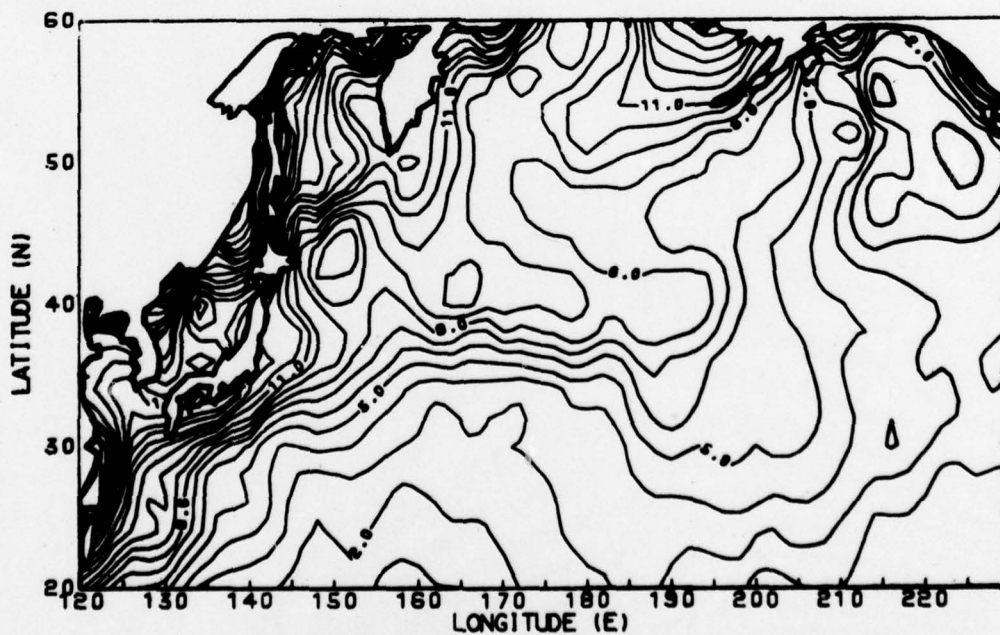


FIGURE 16.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm² sec.

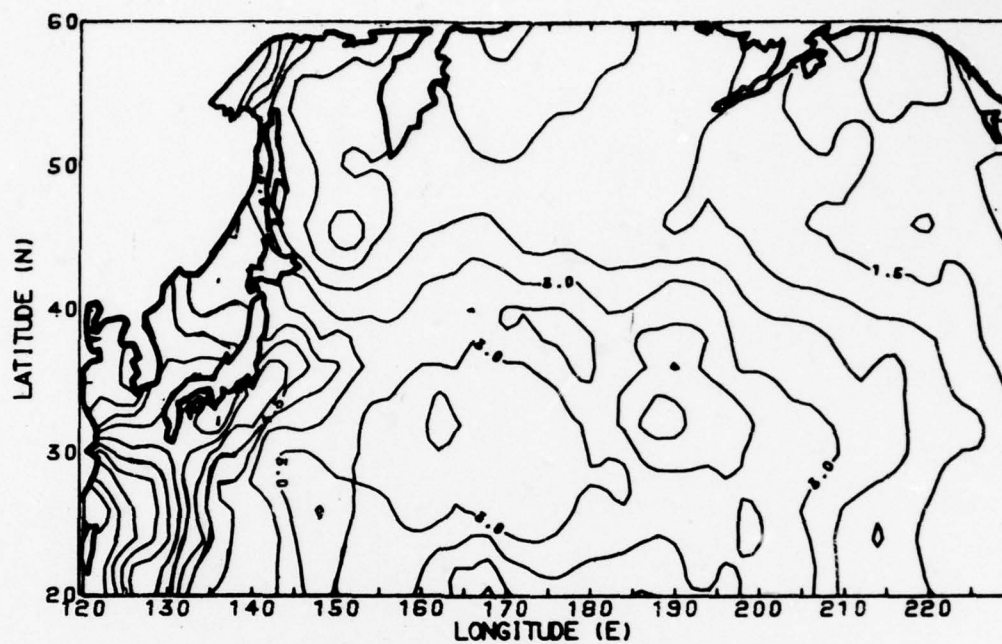


FIGURE 16.11 Monthly mean latent heat flux (ocean to atmosphere) is the mean of 12-hourly latent heat flux calculated from FNWC sea temperature, vapor pressure and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 0.5×10^{-3} cal/cm 2 sec.

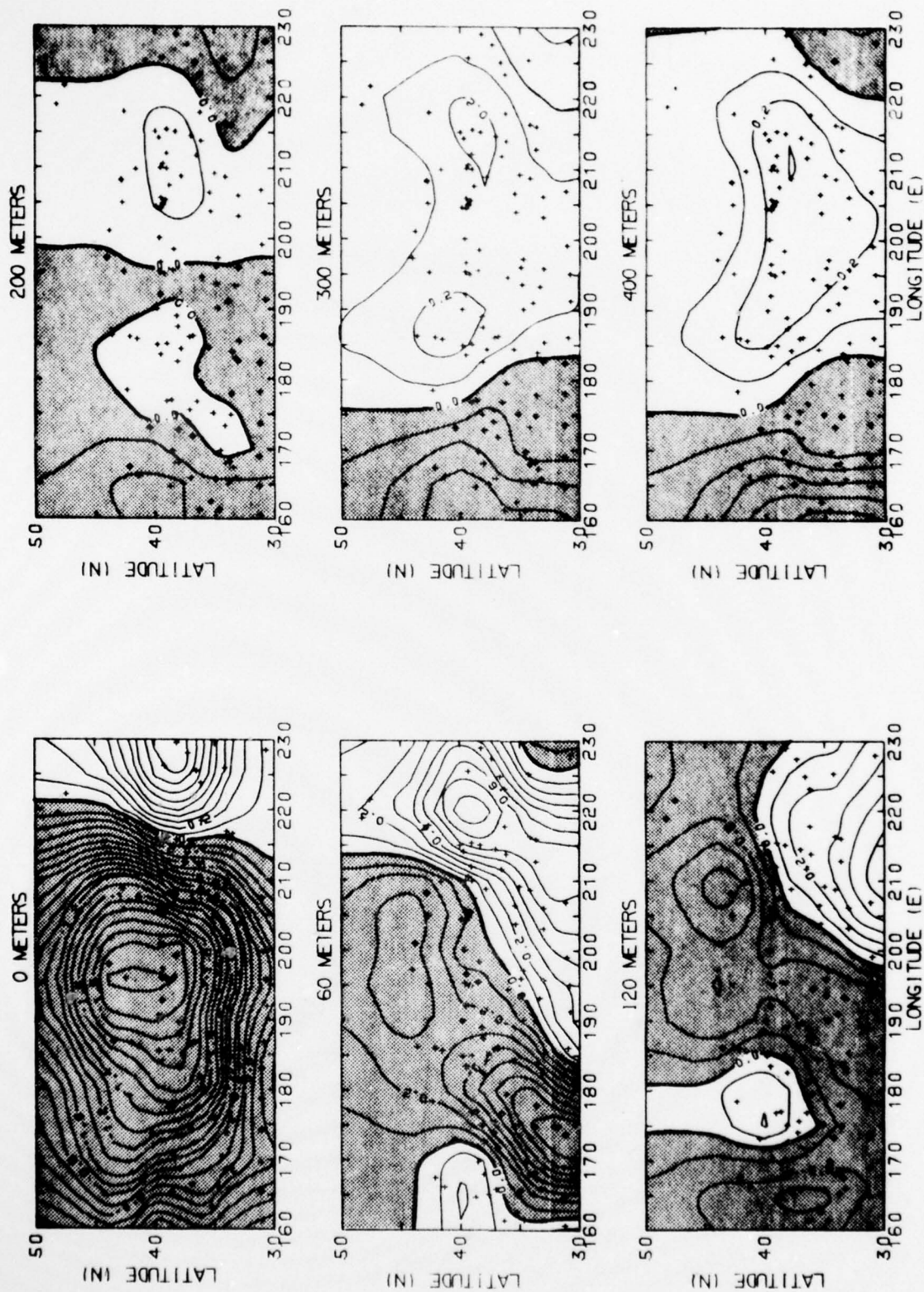


FIGURE 17. Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

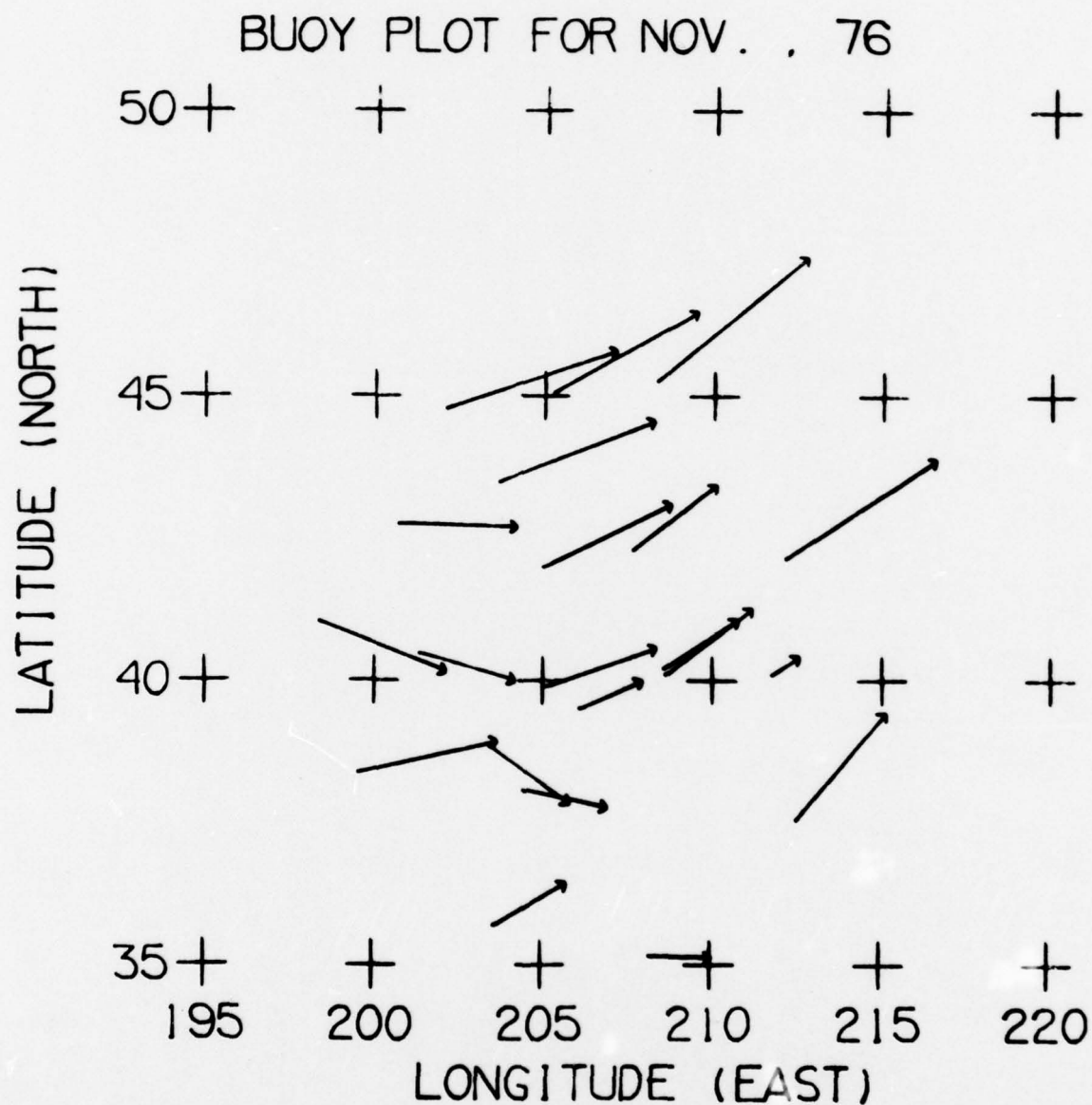


FIGURE 18.

Monthly buoy displacement vectors. Vectors are drawn from start point at beginning of month to terminal point at end of month.

WIND SPEED (M/SEC)

DEC 76

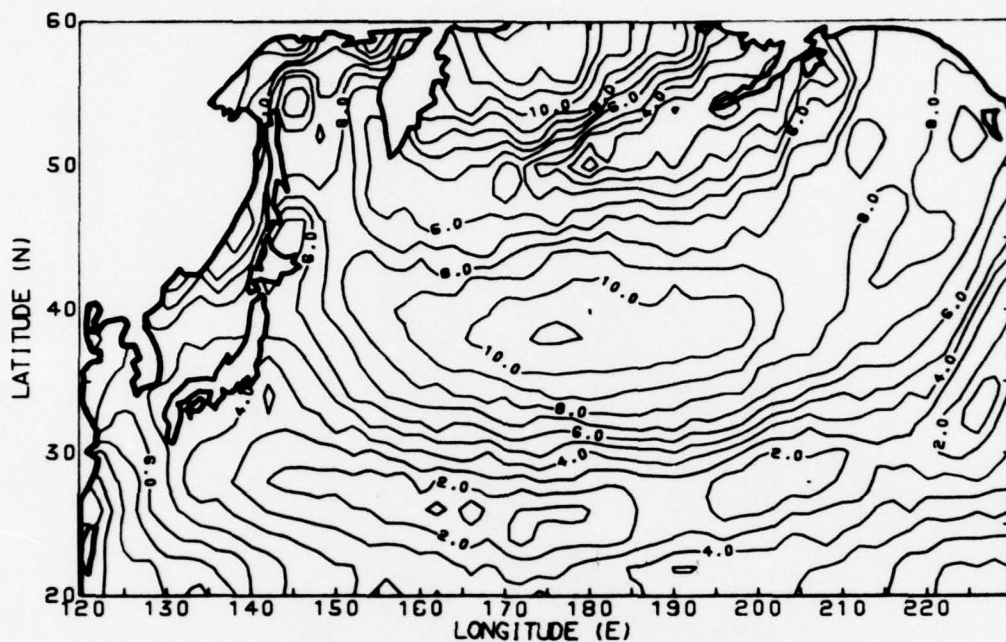


FIGURE 19.1 Absolute value of monthly mean vector wind velocities at 19.5 meters. Contour intervals are 1 m/sec.

WIND DIRECTION

DEC 76

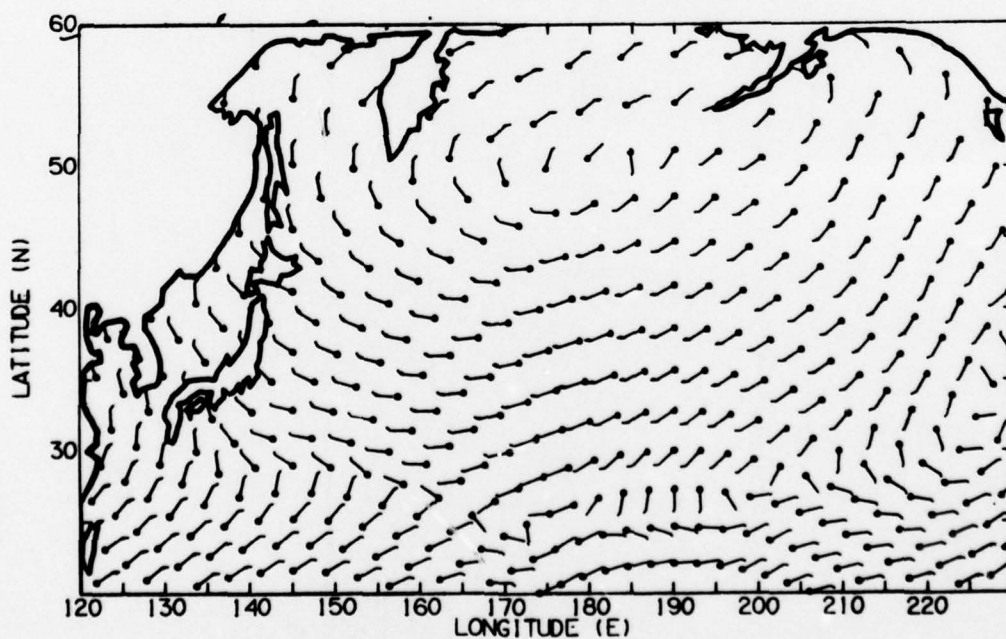


FIGURE 19.2 Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vanes on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

WIND STRESS (DYNES/CM^{••2})

DEC 76

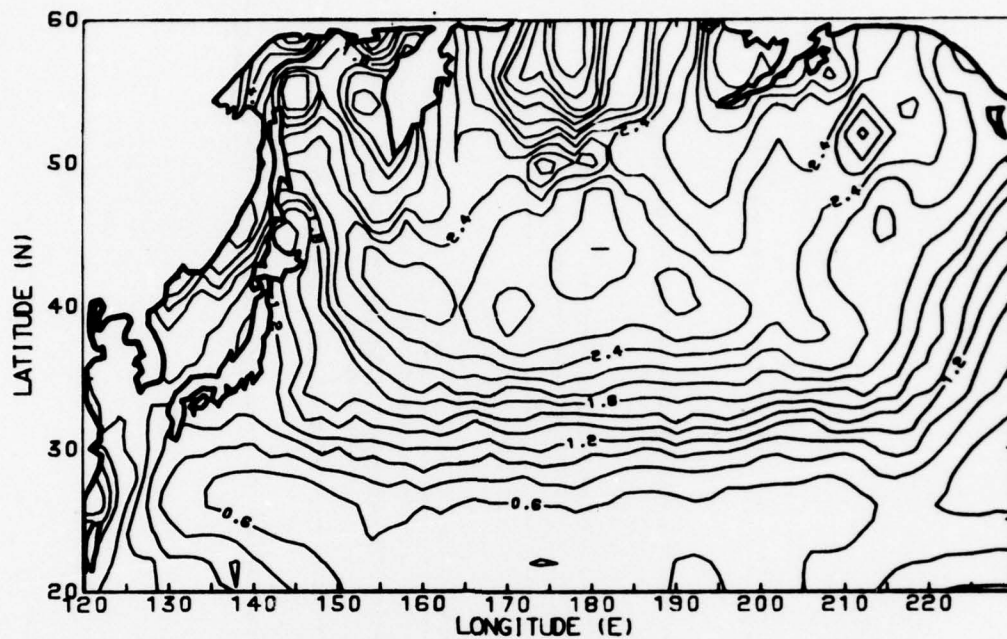


FIGURE 19.3 Monthly mean wind stress is the mean of 6-hourly wind stress at 10 meters calculated from FNWC wind data. Contour intervals are 0.2 dynes/cm^{••2}.

CURL OF WIND STRESS (10^{••9} DYNES/CM^{••3})

DEC 76

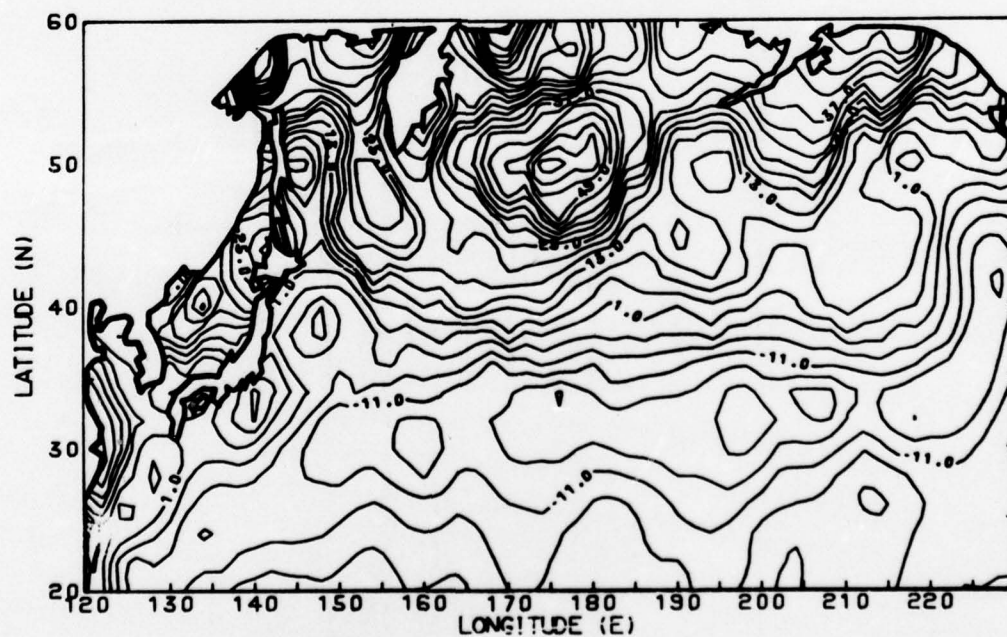


FIGURE 19.4 The vertical component of monthly mean wind stress curl is the mean of 6-hourly wind stress curl approximated by finite-differences from 6-hourly wind stresses at 10 meters. Isolines of zero curl are plotted heavily, and contour intervals are $4.0 \times 10^{\cdot\cdot 9}$ dynes/cm^{••3}.

U STAR CUBED ((M/SEC)**3)

DEC 76

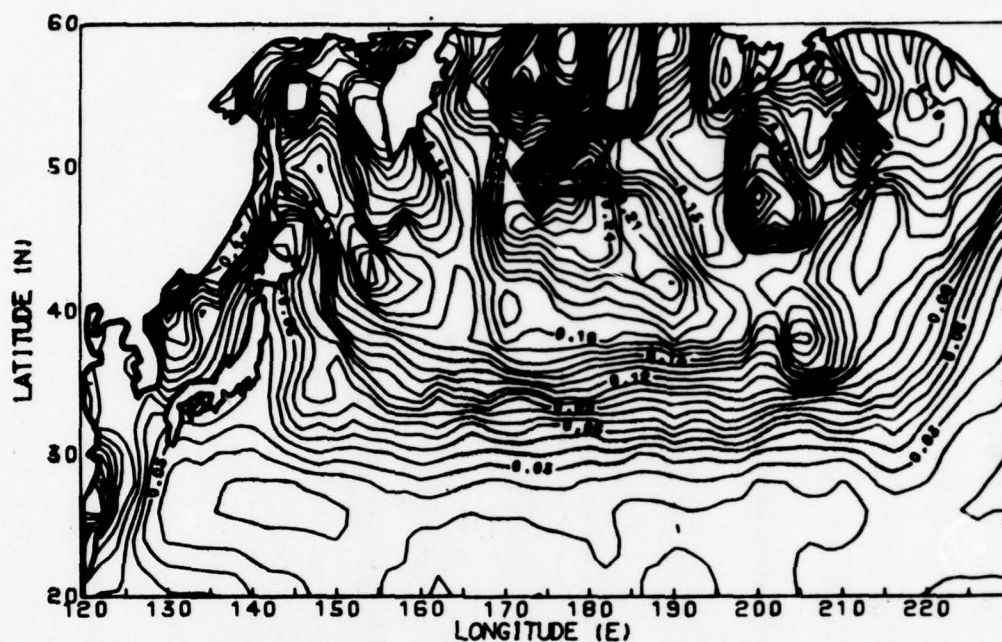


FIGURE 19.5 Monthly mean wind shear stress velocity cubed, U_*^3 is the mean of 6-hourly wind shear stress velocity cubed calculated from wind speed at 10 meters. Contour intervals are 0.04 (m/sec)³.

SEA SURFACE TEMPERATURE (DEG.C)

DEC 76

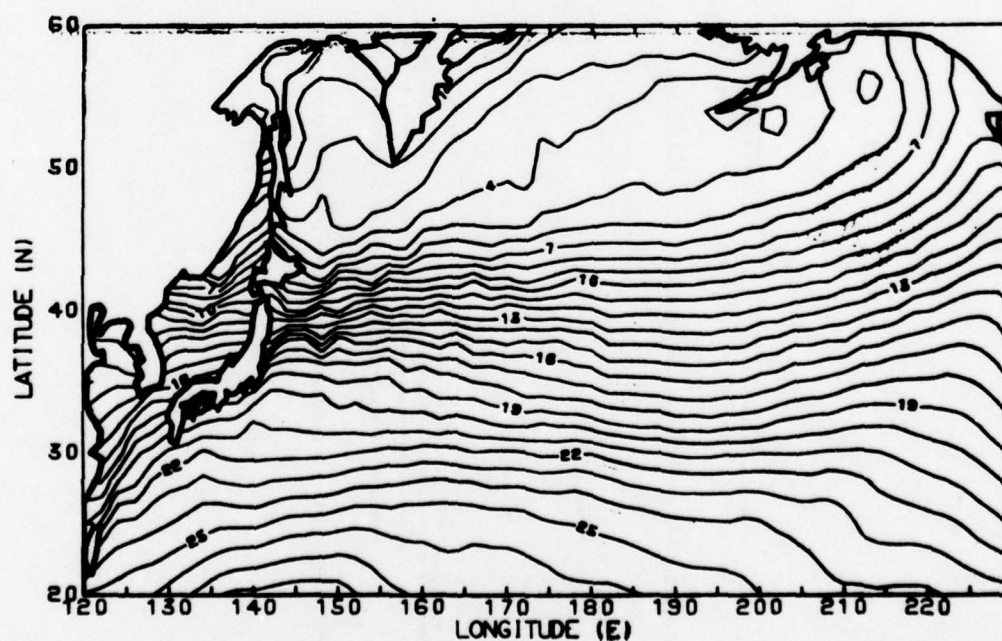


FIGURE 19.6 Monthly mean sea surface temperature is the mean of 12-hourly FNWC sea surface temperatures. Contour intervals are 1°C.

AIR TEMPERATURE (DEG. C) DEC 76

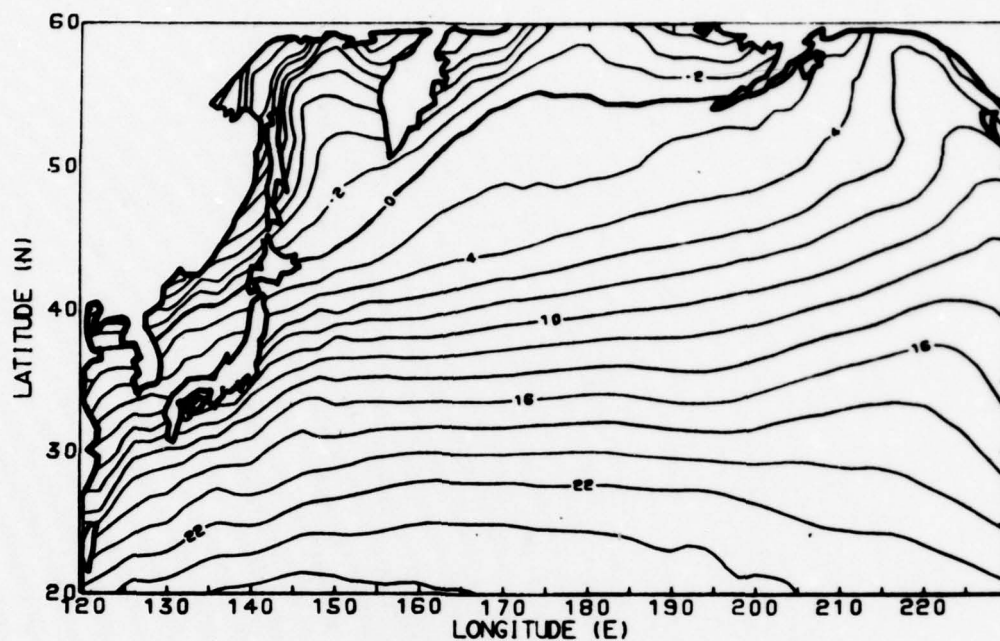


FIGURE 19.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) DEC 76

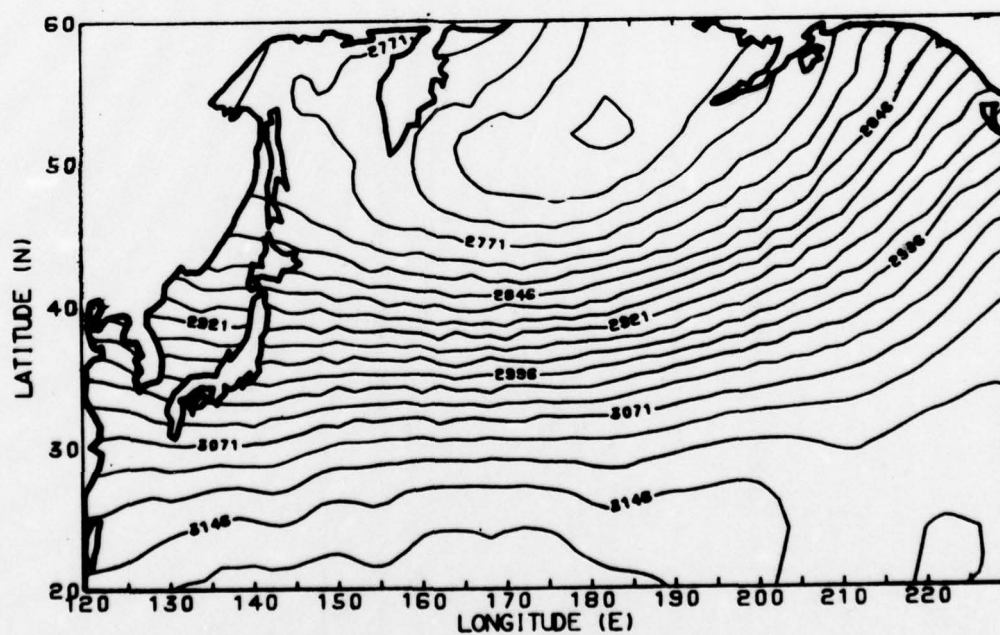


FIGURE 19.8 Monthly mean 700 mb height is the mean of 12-hourly FNWC 700 mb heights. Contour intervals are 25 meters.

VAPOR PRESSURE (MB)

DEC 76

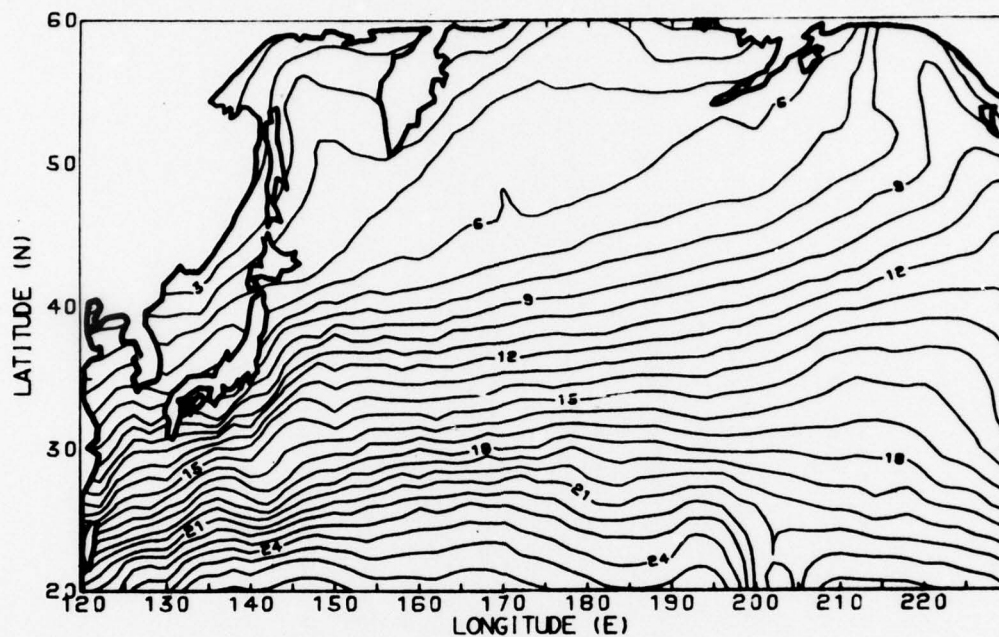


FIGURE 19.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM² SEC)

DEC 76

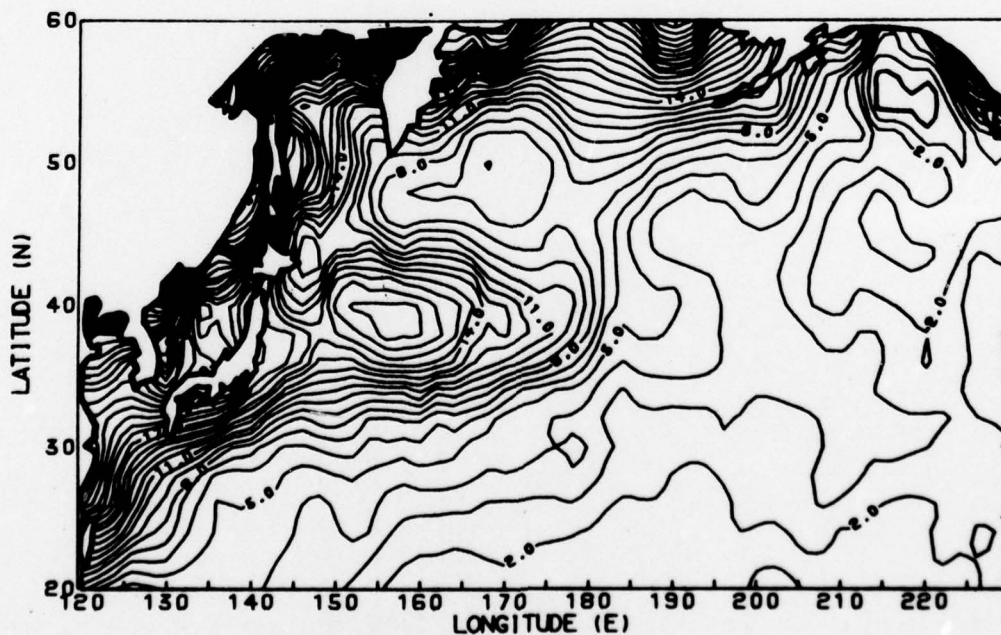


FIGURE 19.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm² sec.

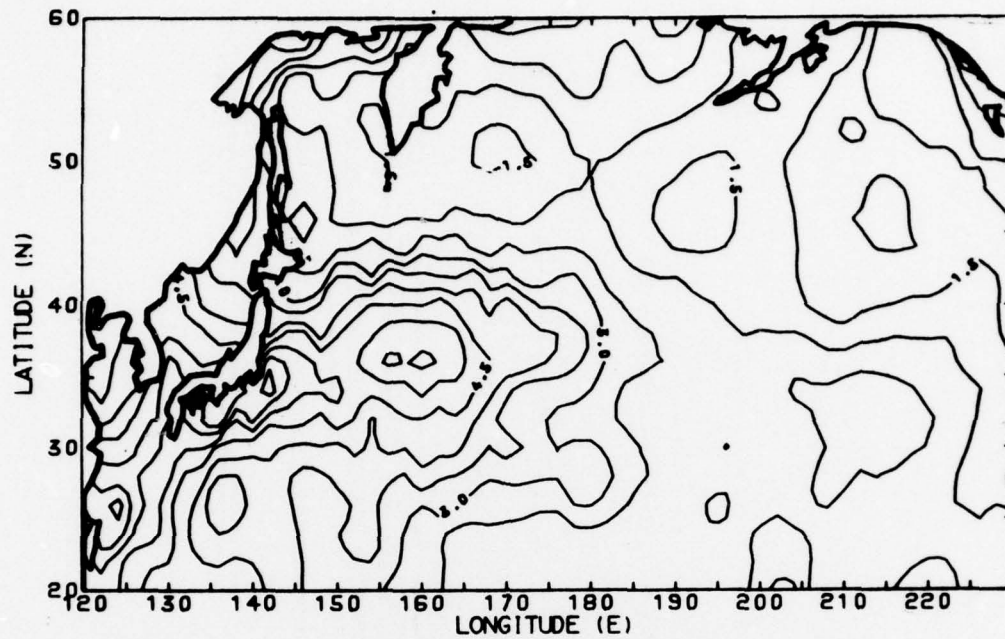


FIGURE 19.11 Monthly mean latent heat flux (ocean to atmosphere) is the mean of 12-hourly latent heat flux calculated from FNWC sea temperature, vapor pressure, and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 0.5×10^{-3} cal/cm 2 sec.

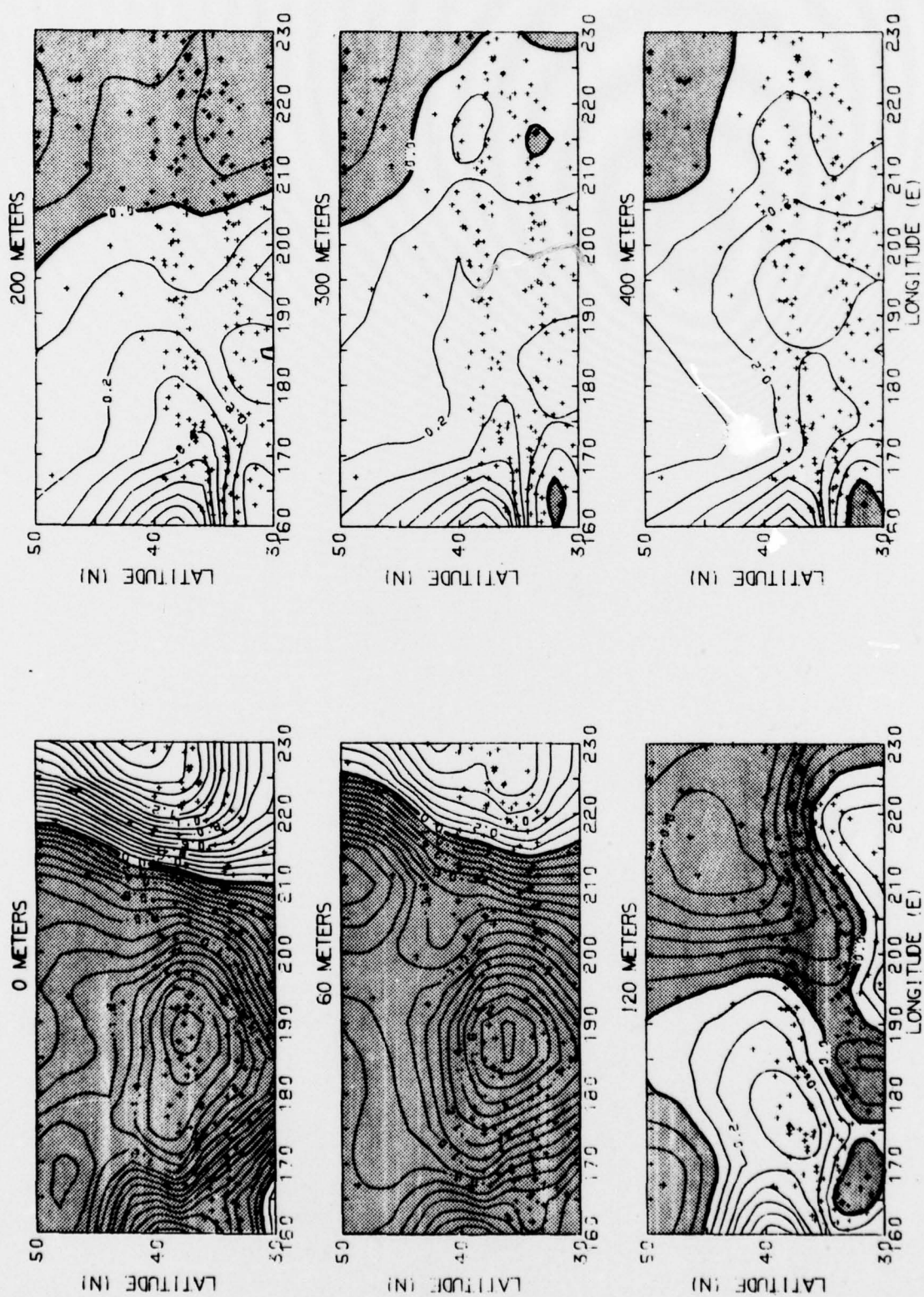


FIGURE 20 Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

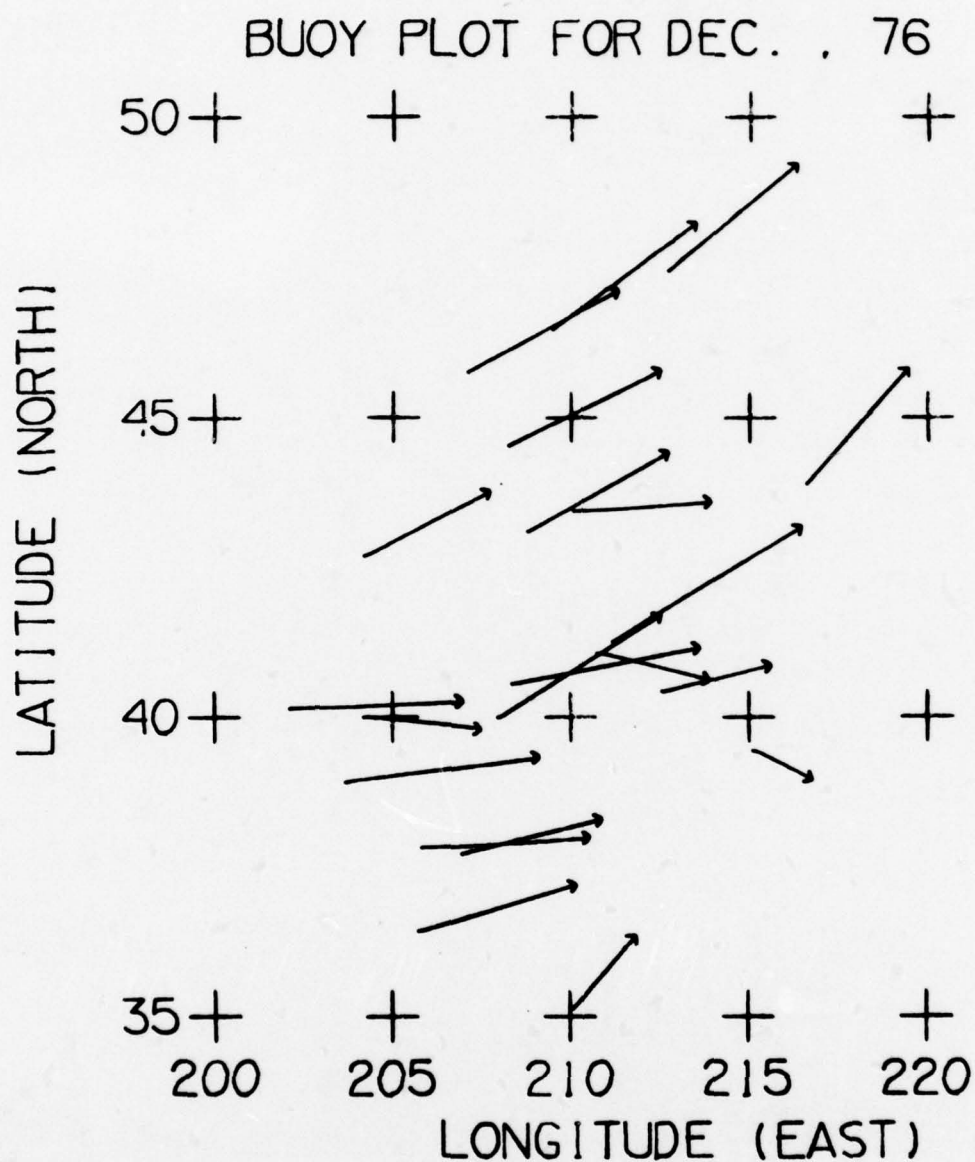


FIGURE 21.

Monthly buoy displacement vectors. Vectors are drawn from start point at beginning of month to terminal point at end of month.

WIND SPEED (M/SEC)

JAN 77

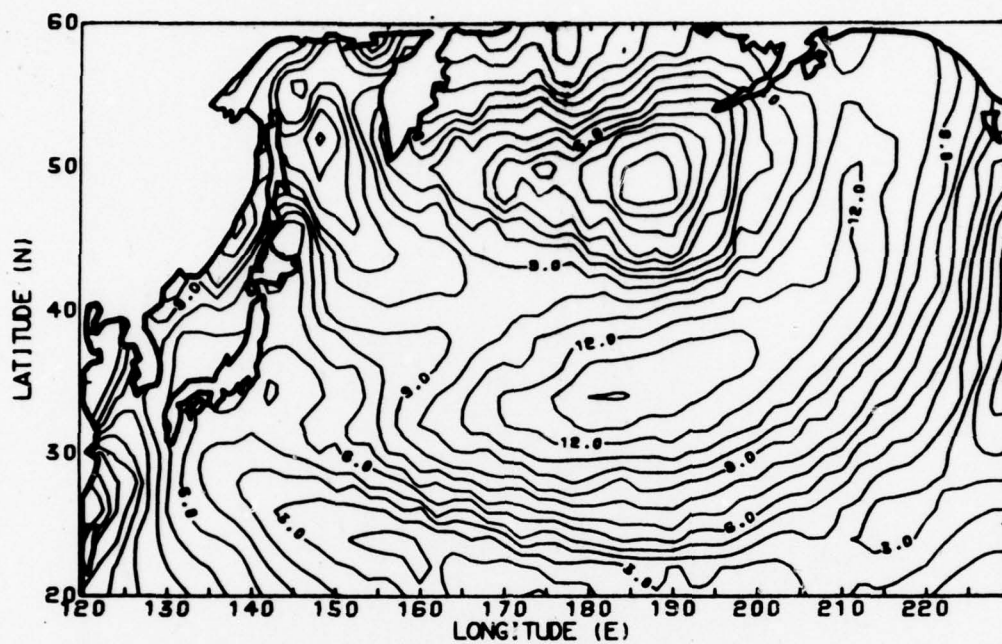


FIGURE 22.1 Absolute value of monthly mean vector wind velocities at 19.5 meters. Contour intervals are 1 m/sec.

WIND DIRECTION

JAN 77

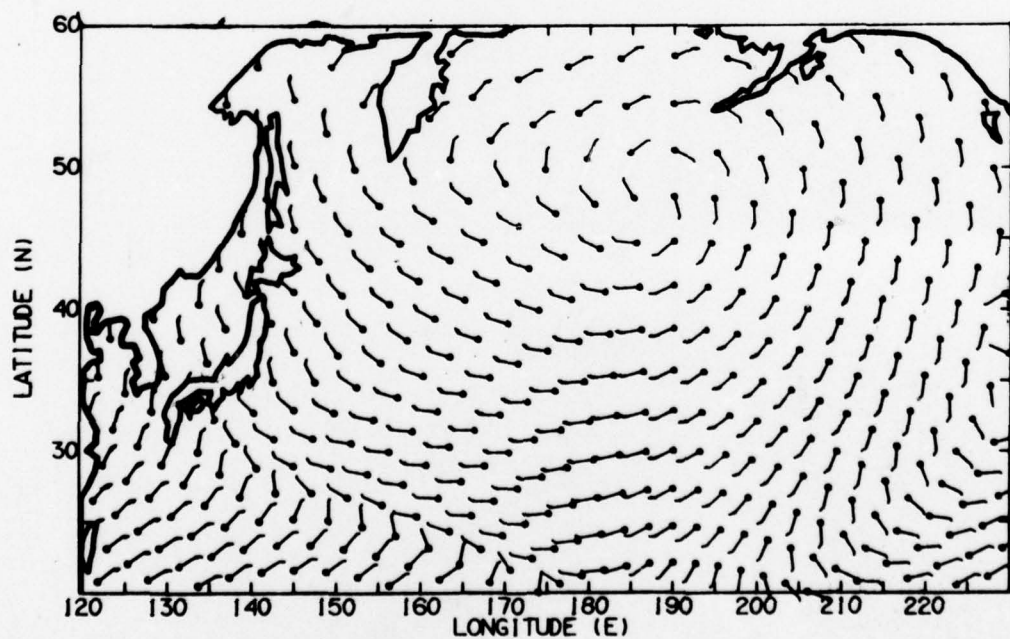


FIGURE 22.2 Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vanes on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

WIND STRESS (DYNES/CM²)

JAN 77

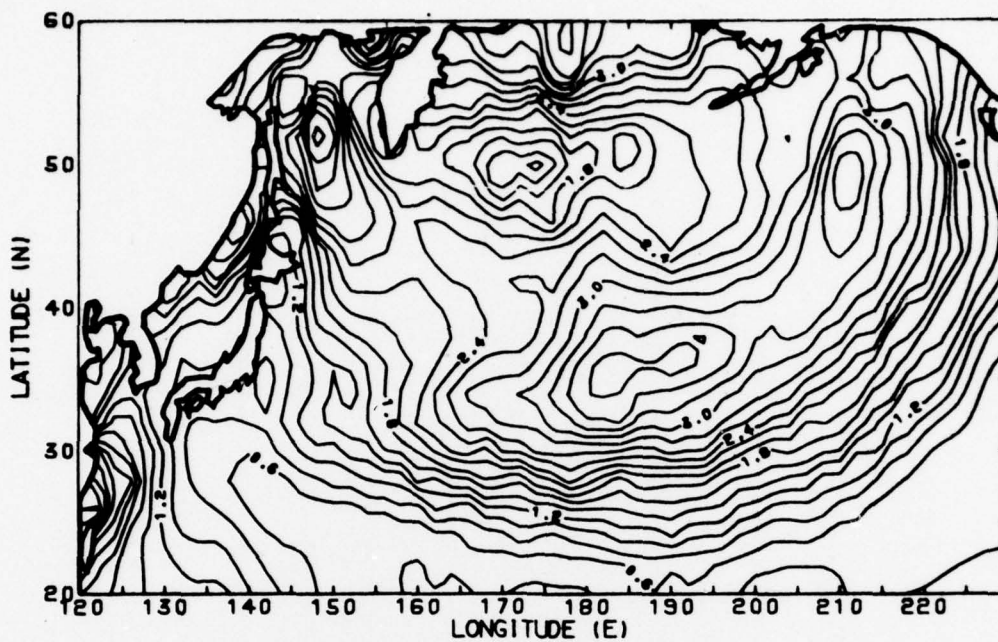


FIGURE 22.3 Monthly mean wind stress is the mean of 6-hourly wind stress at 10 meters calculated from FNWC wind data. Contour intervals are 0.2 dynes/cm²

CURL OF WIND STRESS (10^{-9} DYNES/CM³)

JAN 77

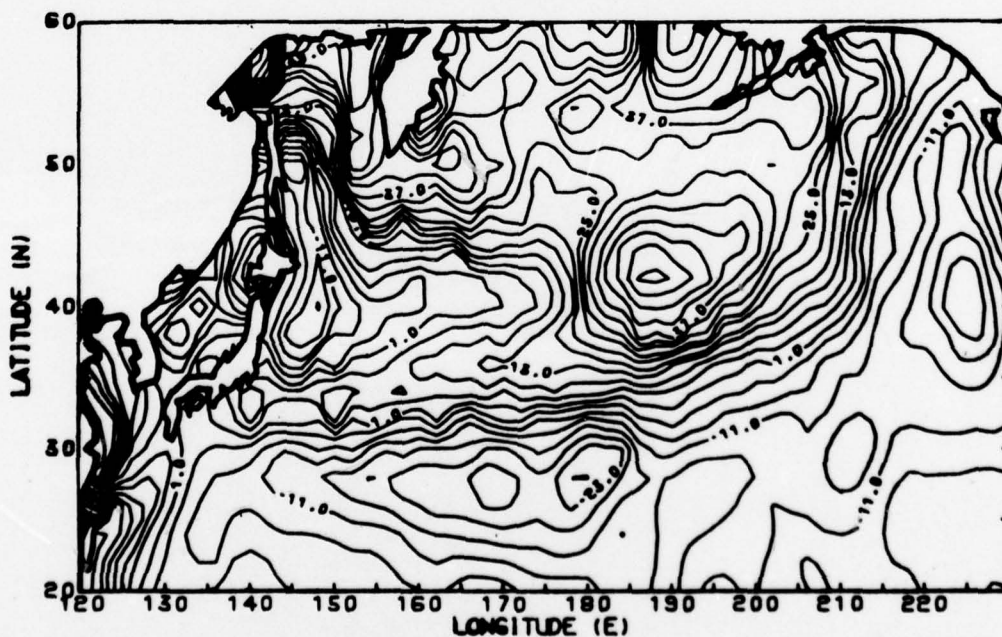
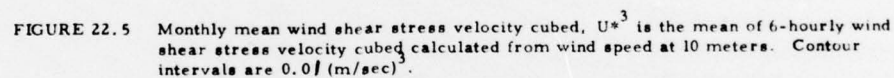
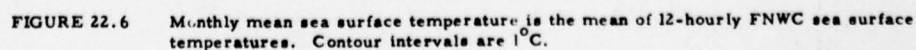


FIGURE 22.4 The vertical component of monthly mean wind stress curl is the mean of 6-hourly wind stress curl approximated by finite-differences from 6-hourly wind stresses at 10 meters. Isolines of zero curl are plotted heavily, and contour intervals are 4.0×10^{-9} dynes/cm³.

JAN 77



JAN 77



AIR TEMPERATURE (DEG. C) JAN 77

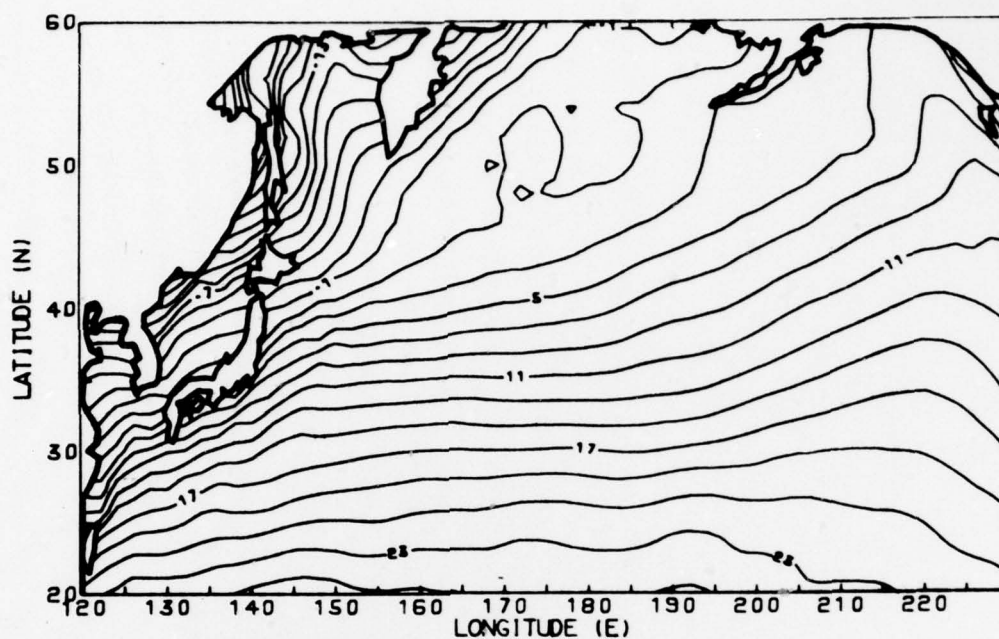


FIGURE 22.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) JAN 77

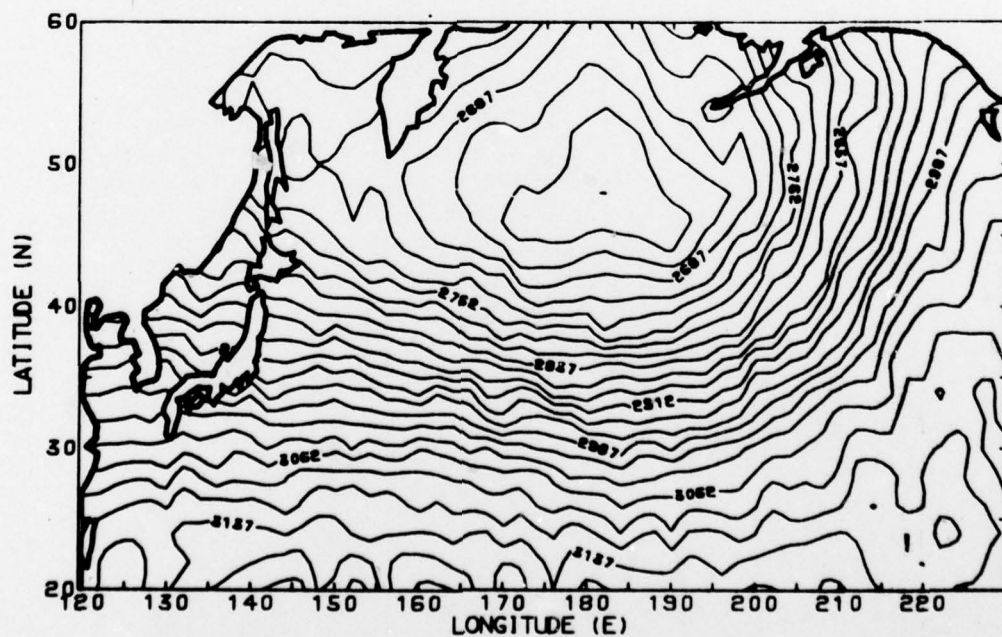


FIGURE 22.8 Monthly mean 700 mb height is the mean of 12-hourly FNWC 700 mb heights. Contour intervals are 25 meters.

VAPOR PRESSURE (MB) JAN 77

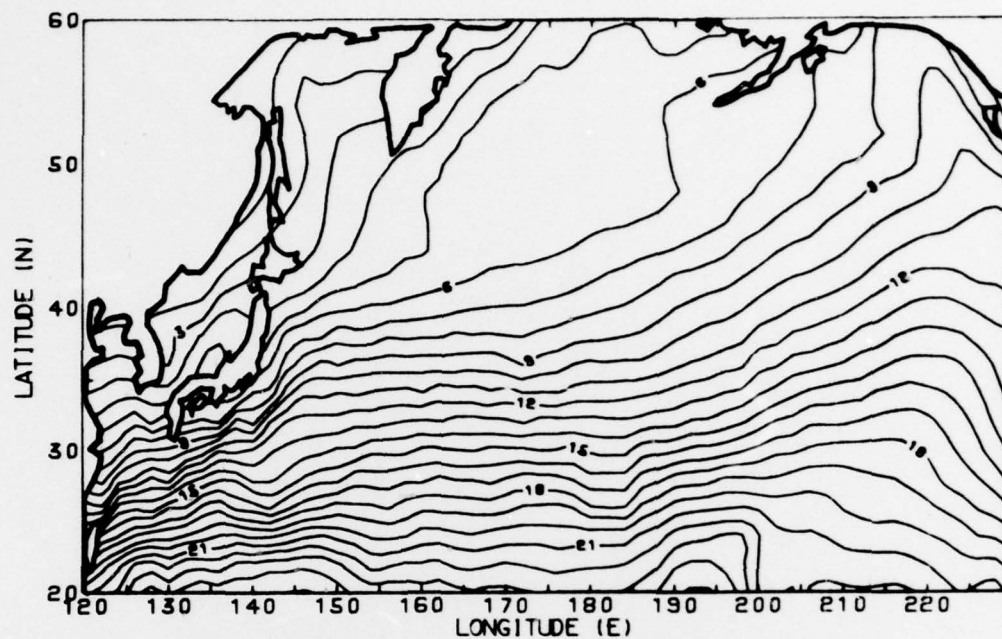


FIGURE 22.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM 2 SEC) JAN 77

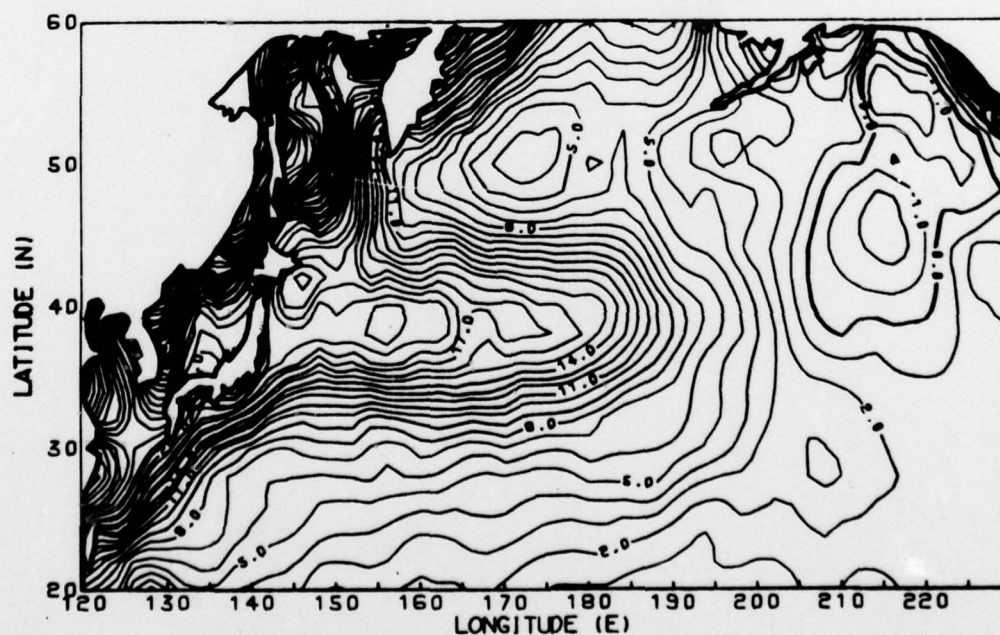


FIGURE 22.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm 2 sec.

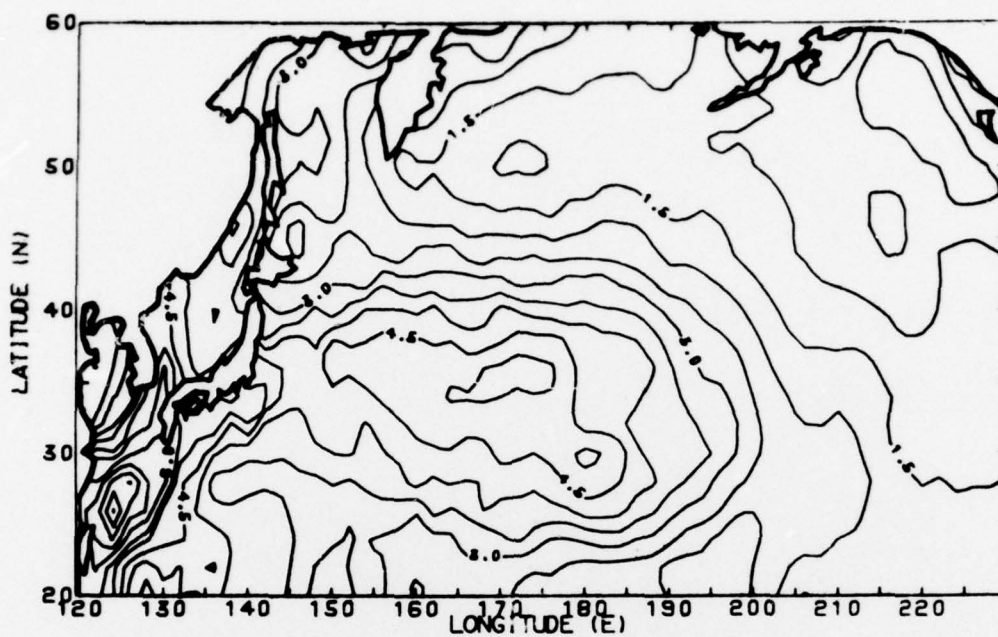


FIGURE 22.11 Monthly mean latent heat flux (ocean to atmosphere) is the mean of 12-hourly latent heat flux calculated from FNWC sea temperature, vapor pressure and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 0.5×10^{-3} cal/cm 2 sec.

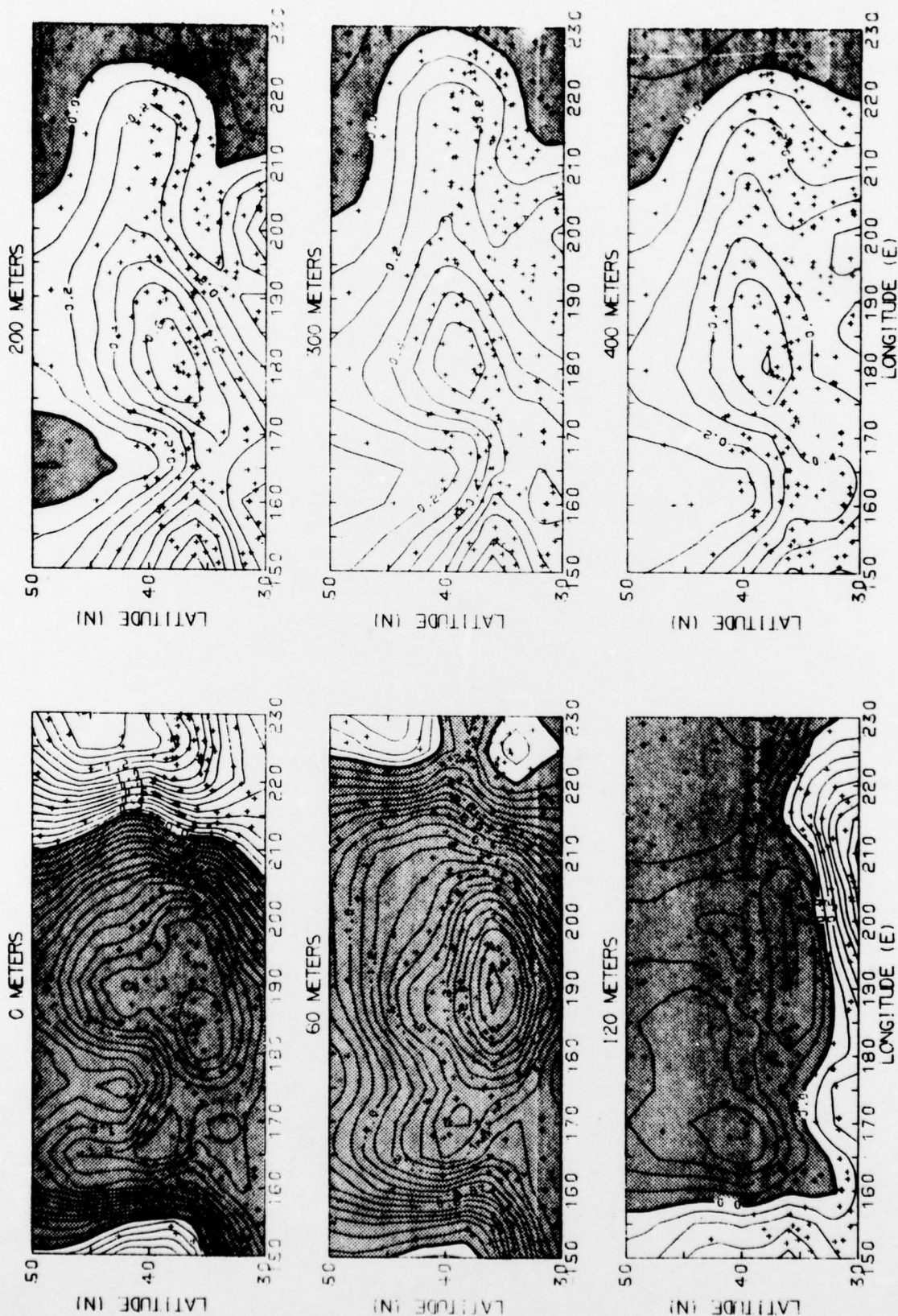


FIGURE 23. Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

WIND SPEED (M/SEC)

FEB 77

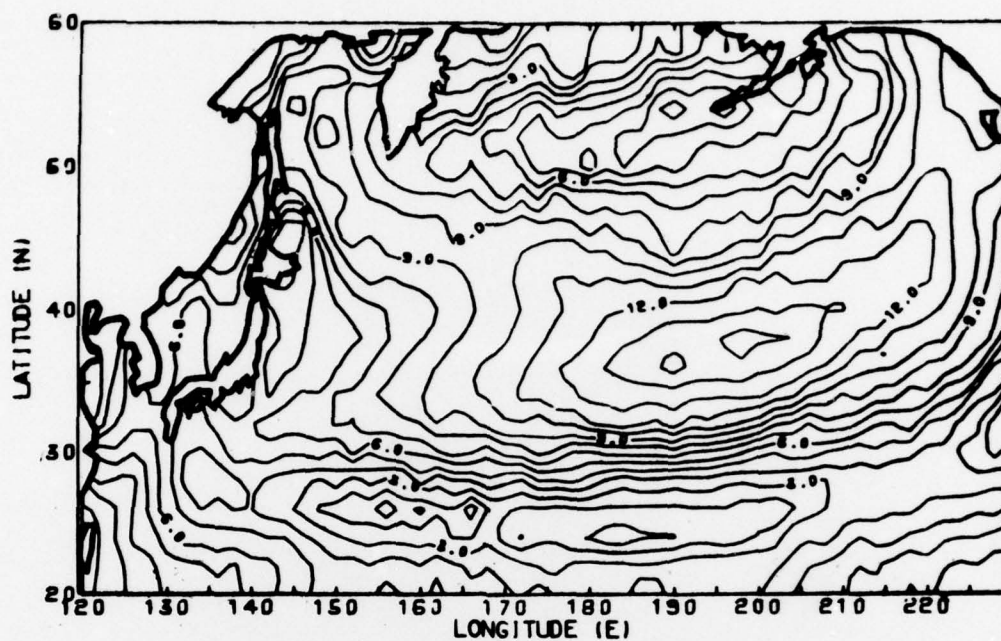


FIGURE 24.1 Absolute value of monthly mean vector wind velocities at 19.5 meters. Contour intervals are 1 m/sec.

WIND DIRECTION

FEB 77

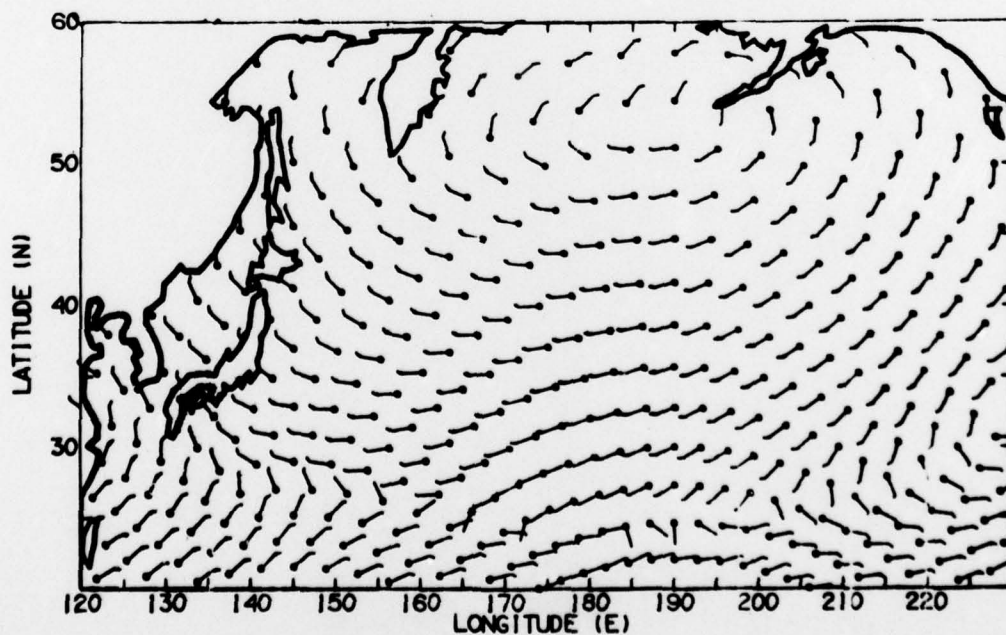


FIGURE 24.2 Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vanes on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

WIND STRESS (DYNES/CM²)

FEB 77

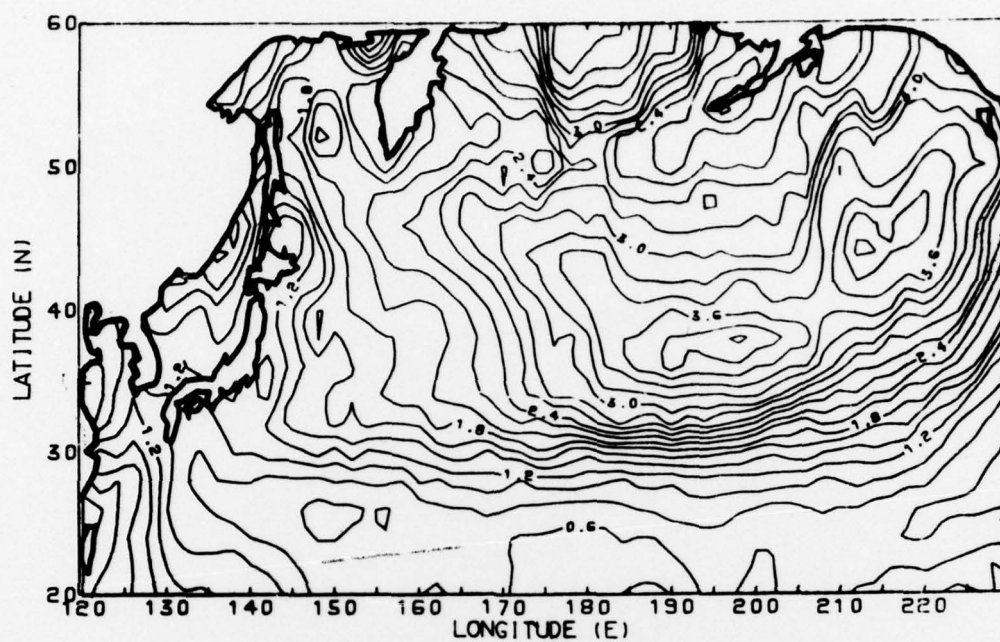


FIGURE 24.3 Monthly mean wind stress is the mean of 6-hourly wind stress at 10 meters calculated from FNWC wind data. Contour intervals are 0.2 dynes/cm².

CURL OF WIND STRESS (10^{-9} DYNES/CM³)

FEB 77

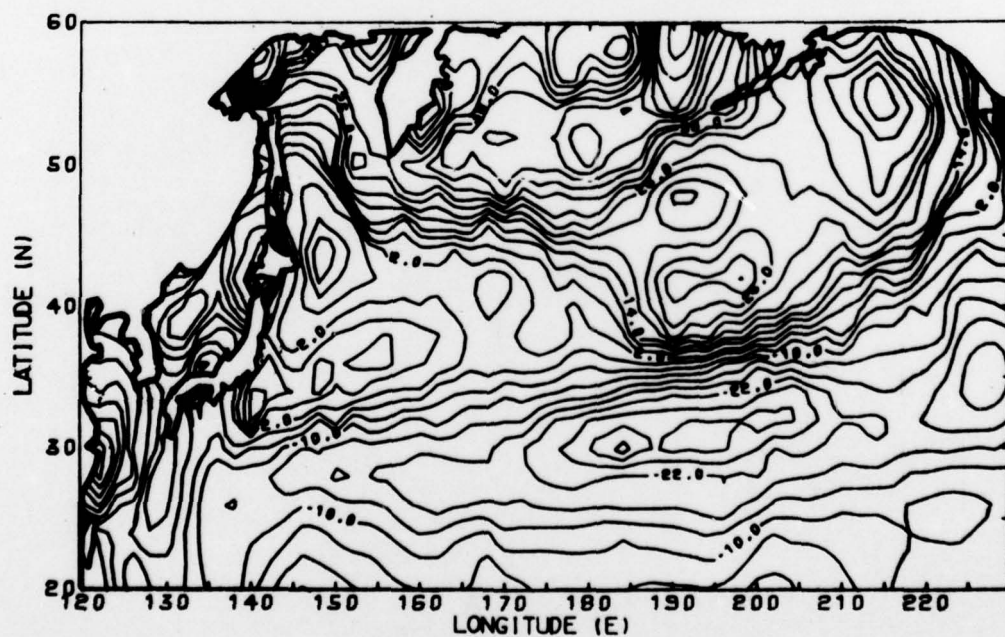


FIGURE 24.4 The vertical component of monthly mean wind stress curl is the mean of 6-hourly wind stress curl approximated by finite-differences from 6-hourly wind stresses at 10 meters. Isolines of zero curl are plotted heavily, and contour intervals are 4.0×10^{-9} dynes/cm³.

U STAR CUBED ((M/SEC)**3)

FEB 77

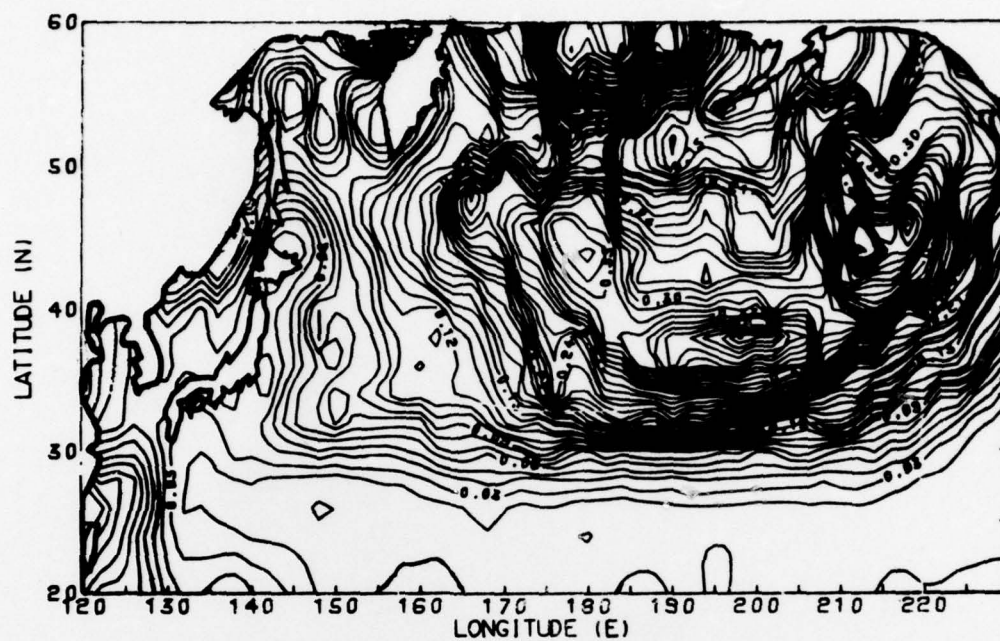


FIGURE 24.5 Monthly mean wind shear stress velocity cubed, U_*^3 is the mean of 6-hourly wind shear stress velocity cubed calculated from wind speed at 10 meters. Contour intervals are 0.04 $(\text{m/sec})^3$.

SEA SURFACE TEMPERATURE (DEG.C)

FEB 77

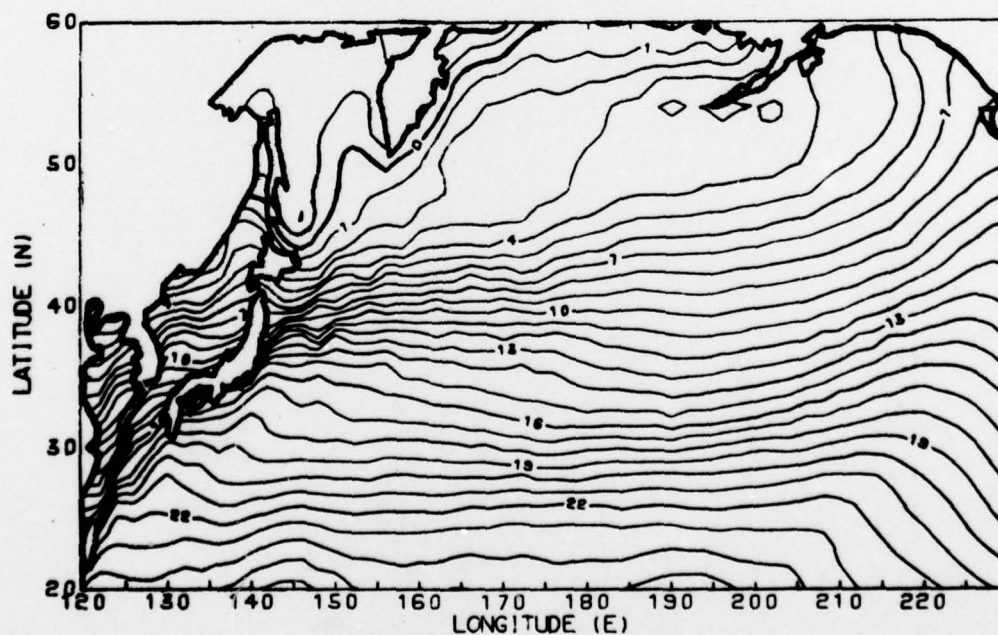


FIGURE 24.6 Monthly mean sea surface temperature is the mean of 12-hourly FNWC sea surface temperatures. Contour intervals are 1°C.

AIR TEMPERATURE (DEG. C) FEB 77

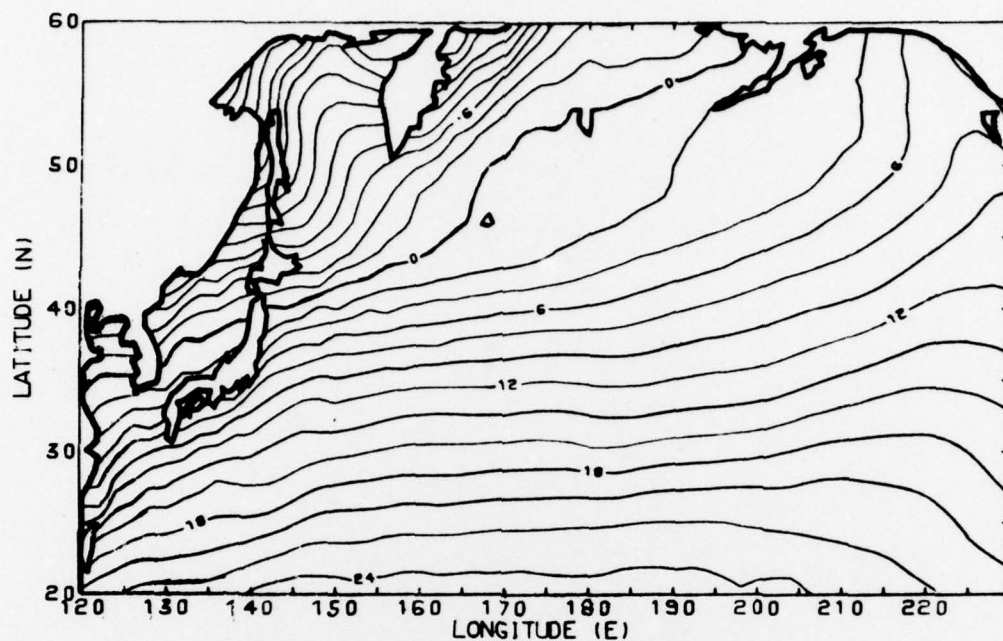
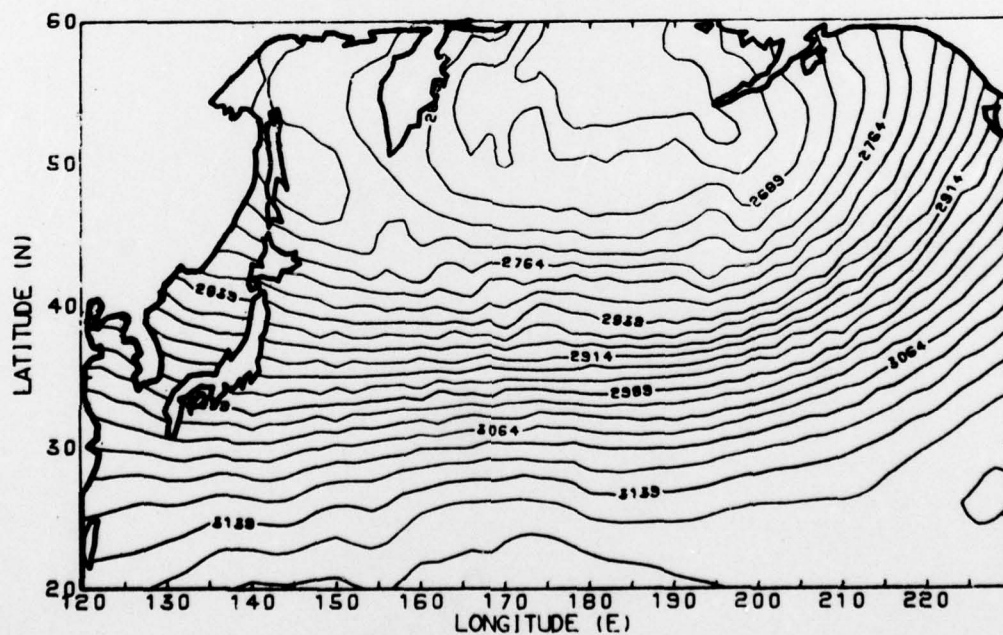


FIGURE 24.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) FEB 77



VAPOR PRESSURE (MB) FEB 77

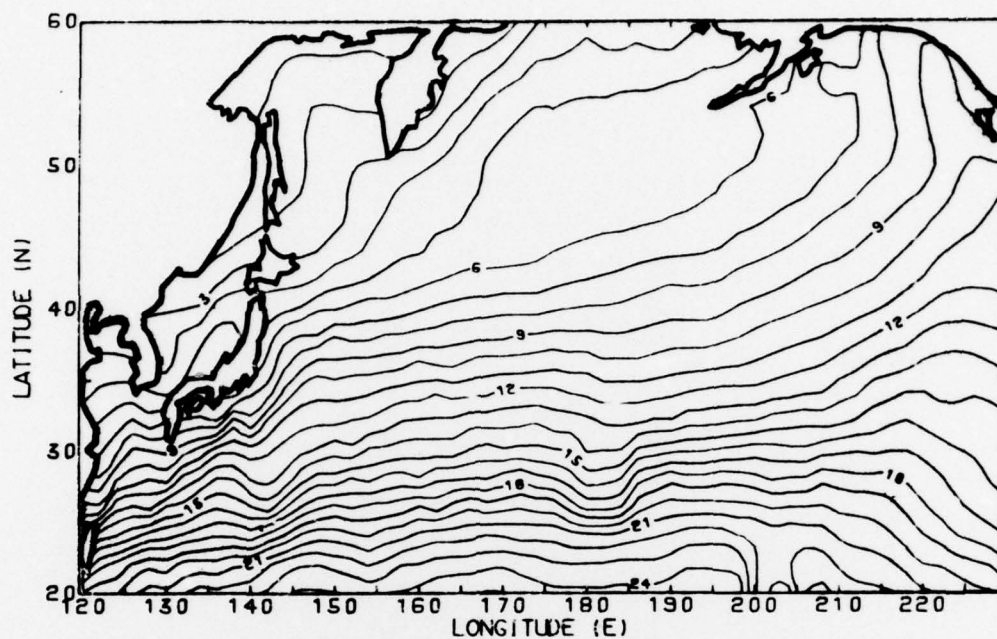


FIGURE 24.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM 2 SEC) FEB 77

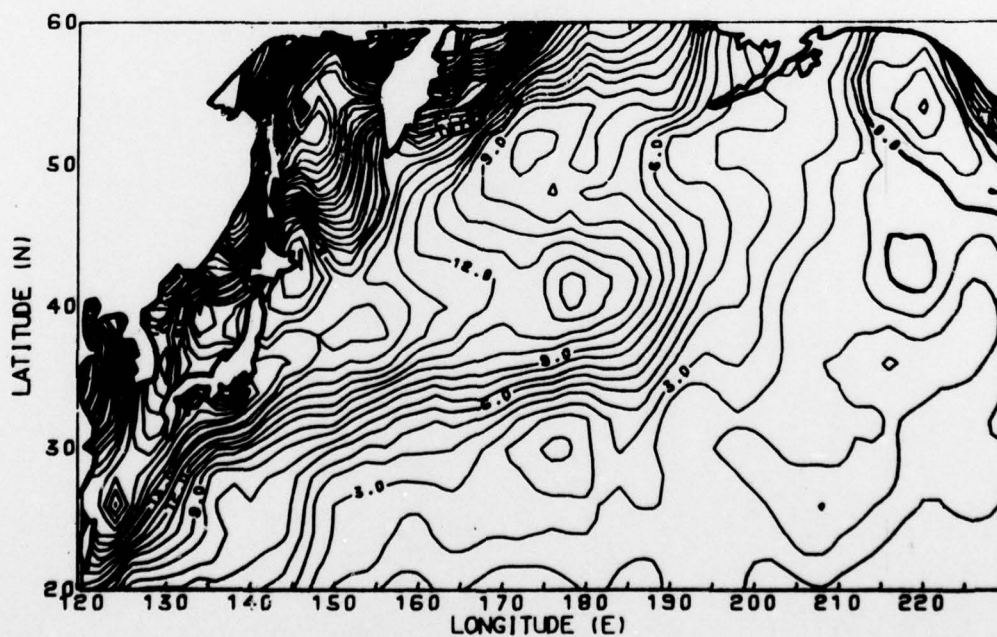


FIGURE 24.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm 2 sec.

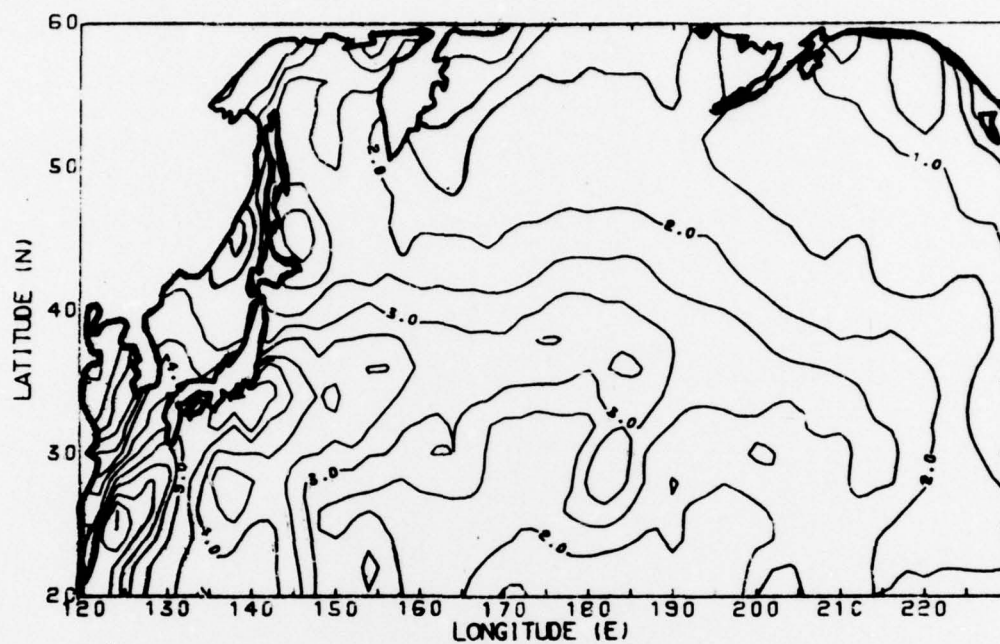


FIGURE 24.11 Monthly mean latent heat flux (ocean to atmosphere) is the mean of 12-hourly latent heat flux calculated from FNWC sea temperature, vapor pressure and wind using a bulk formula. Isojines of zero heat flux are plotted heavily, and contour intervals are 0.5×10^{-3} cal/cm 2 sec.

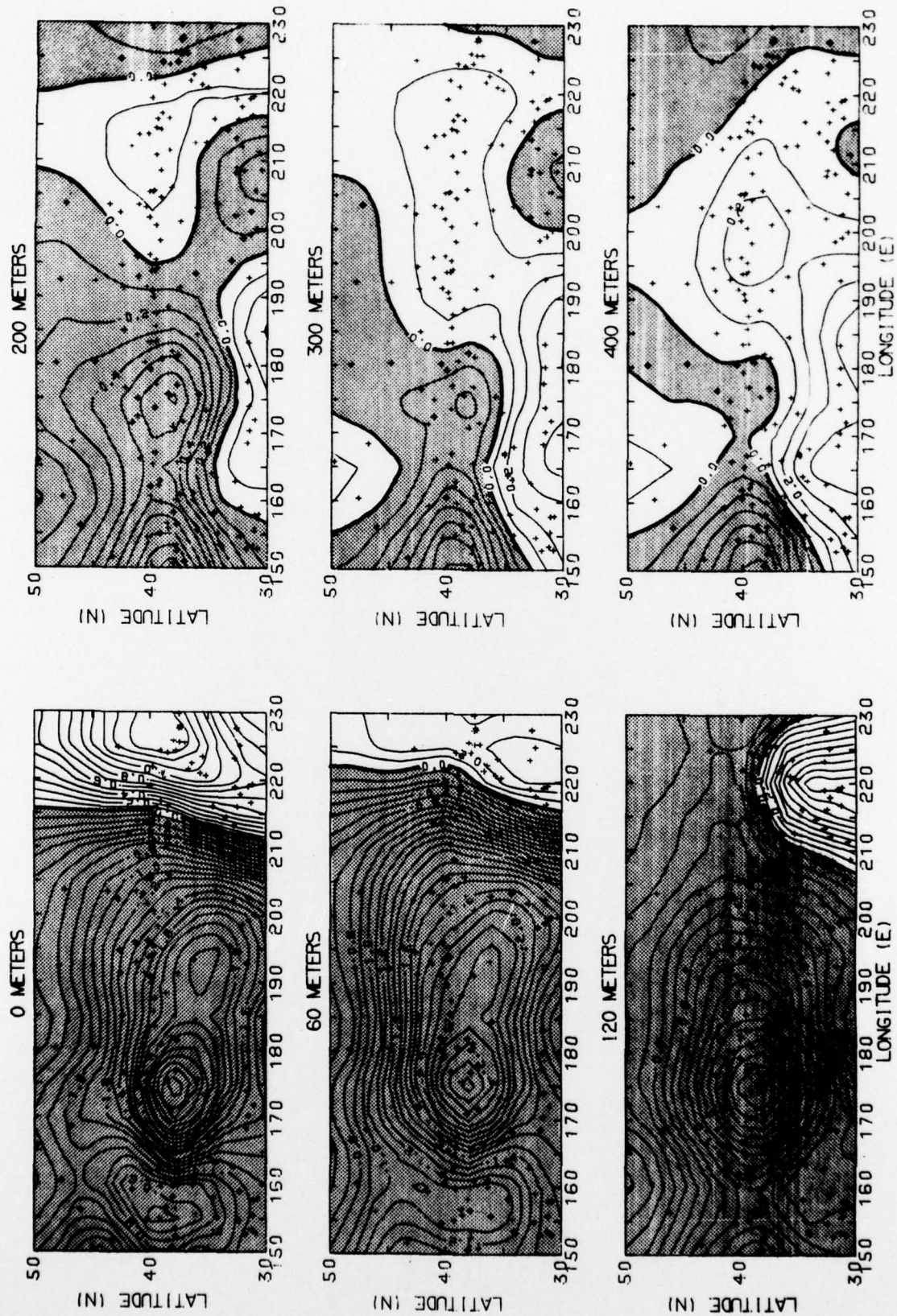


FIGURE 25. Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

APPENDIX A

The vertical component of wind stress curl,

$$\hat{r} \cdot \text{curl } \vec{\tau} = \frac{1}{r} \left(\frac{\partial \tau_{NS}}{\cos \varphi \partial \theta} - \frac{\partial \tau_{EW}}{\partial \varphi} \right), \quad (1)$$

was calculated on the FNWC polar grid using the chain rule and differentiating the polar projection mapping equations,

$$\xi = 32 + 31.205 \cdot \left(\frac{1 - \sin \varphi}{1 + \sin \varphi} \right)^{1/2} \cdot \sin(\theta + 80) \quad (2a)$$

$$\eta = 32 + 31.205 \cdot \left(\frac{1 - \sin \varphi}{1 + \sin \varphi} \right)^{1/2} \cdot \cos(\theta + 80), \quad *(2b)$$

where

τ_{NS} = north-south component of wind stress

τ_{EW} = east-west component of wind stress

φ = latitude

θ = longitude

r = earth radius

ξ = horizontal axis of rectilinear
grid on a polar projection
in Figure 1

η = vertical axis of grid in Figure 1.

Finite difference expressions for equation (1) were:

* The factors in this equation, 33 and 31.205, are specific to FNWC's 63 x 63 grid.

$$\frac{\partial \tau_{NS}}{\partial \theta} = \frac{1}{2} (\tau_{NS, i+1, j} - \tau_{NS, i-1, j}) \frac{\partial \xi}{\partial \theta} + \frac{1}{2} (\tau_{NS, i, j+1} - \tau_{NS, i, j-1}) \frac{\partial \eta}{\partial \theta} \quad (3a)$$

$$\frac{\partial \tau_{EW}}{\partial \varphi} = \frac{1}{2} (\tau_{EW, i+1, j} - \tau_{EW, i-1, j}) \frac{\partial \xi}{\partial \varphi} + \frac{1}{2} (\tau_{EW, i, j+1} - \tau_{EW, i, j-1}) \frac{\partial \eta}{\partial \varphi} \quad (3b)$$

where

$i = 0, \dots, 62$; discrete values of ξ

$j = 0, \dots, 32$; discrete values of η .

When equations (3a) and (3b) were substituted into equations (2a) and (2b), a finite difference expression for the vertical component of wind stress curl was obtained:

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1971: Flux-profile relationships in the atmospheric
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- Friehe, C. and K. Schmitt 1976: Parameterization of air-sea
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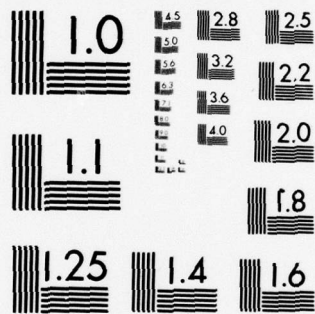
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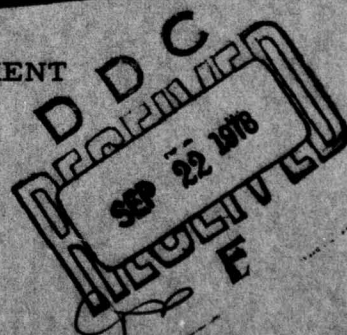
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October, 1977

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7. AUTHOR(s) (10) Steven Paxan	15	6. PERFORMING ORG. REPORT NUMBER 77-19
9. PERFORMING ORGANIZATION NAME AND ADDRESS Scripps Institution of Oceanography La Jolla, CA 92093	11	8. CONTRACT OR GRANT NUMBER(s) N00014-75-C-0152
11. CONTROLLING OFFICE NAME AND ADDRESS Office of Naval Research Arlington, VA 22217		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Oct 77
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (14) SI8-REF-77-19		12. REPORT DATE August 1978
		13. NUMBER OF PAGES 79 pages
		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release: distribution unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
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INTRODUCTION

During the ADS meeting of March 16, 1977 it was decided to produce a NORPAX ADS program data report for trimonthly periods roughly corresponding to seasons.

This is the first issue of that data report, and contains contour maps of monthly mean: FNWC air temperature, sea temperature, wind speed, wind direction, surface vapor pressure, and 700 mb heights; NORPAX calculated wind stress, wind stress curl, wind shear velocity cubed (U^3), ^{U-cubed} sensible heat flux, latent heat flux; objectively analyzed TRANSPAC temperatures at discrete depths from White and Bernstein (SIO). This report also contains monthly drifter buoy displacement vectors from Kirwan (TAMU) and McNally (SIO).

Because of extensive back dating in this first report, the time period from June, 1976 to February, 1977 will be covered.

PROCEDURE AND ANALYSIS

1. FNWC 63 x 63 Northern Hemispheric Fields

FNWC data were taken from 63 x 63 polar gridded fields of 6-hourly wind speed and direction, and 12-hourly 700 mb height, sea surface temperature, air temperature, and vapor pressure.

33 x 63 fields were extracted from the larger fields; geographic coverage of a 33 x 63 field is shown in Figure 1. 10-m level winds and U_{10}^3 were calculated from FNWC winds by an iterative scheme using the neutral flux-profile relationships obtained by Businger et al. (1971). Wind stress was calculated from FNWC wind speed and direction using a bulk aerodynamic equation:

$$\tau = -\rho \overline{uw} = \rho C_D U_{10}^2 \quad (1)$$

where

τ = surface stress

\overline{uw} = Reynolds stress, ($m^2 sec^{-2}$)

ρ = air density

U_{10} = wind speed at 10 m

$C_D = 1.3 \times 10^{-3}$ (drag coefficient found by Smith and Banke (1975) for $U_{10} = 10$ m/sec).

The vertical component of wind stress curl was calculated on the FNWC northern hemispheric grid using polar projection mapping equations and finite difference approximations (Appendix A).

Sensible heat flux (cal/cm sec) was obtained using an empirical bulk formula (Friehe and Schmitt, 1976):

$$S.H.F. = \rho C_p [0.2 \times 10^{-6} + C_H \cdot U_{10} \cdot (T_s - T_A)] \quad (2)$$

where,

$$C_p = 0.24 \text{ cal/gm}^\circ\text{C}$$

$$C_m = 0.91 \times 10^{-7}$$

$$T_s = \text{sea surface temperature}$$

$$T_A = (10 \text{ meter}) \text{ air temperature}$$

The latent heat flux ($\text{cal/cm}^2\text{sec}$) was also calculated from a bulk formula (Friehe and Schmitt, 1976):

$$L.H.F. = L \cdot C_E \cdot U_{10} \cdot [Q_{SEA} - Q] \quad (3)$$

$$L = 595 \text{ cal/gm (heat of evaporation)}$$

$$C_E = 1.32 \times 10^{-3}$$

$$Q = 0.75 [EAIR (\text{gm} \cdot \text{m}^{-3}) = \text{FNWC vapor pressure}]$$

$$Q_{SEA} = \text{vapor density near the sea surface}$$

$$= 1.667 \times 10^{-7} [e^{17.19[(T_s + 273)/273]}]$$

Stress, stress-curl and U_z^3 fields were calculated at 00z, 06z, 12z, 18z GMT; heat fluxes were calculated for 00z and 12z GMT every day. These calculated fields were then averaged to obtain daily, 5-daily, and monthly means. North and east-wind components were meaned to obtain daily, 5-daily, and monthly vector means of wind speed and direction. Monthly means were contoured over the region of the North Pacific from 120E to 230E and 20N to 60N. These contour maps are grouped by month in the present report in Figures 2.1-2.11, 4.1-4.11, 7.1-7.11, 10.1-10.11, 13.1-13.11, 16.1-16.11, 19.1-19.11, 22.1-22.11, and

24.1-24.11.

2. Objectively Analyzed Transpac XBT

XBTs have been regularly dropped from ships of opportunity in the Pacific since 1974. Recovered temperature profile data have been analyzed at Scripps by Bernstein and White and temperature residuals from their 1968 to 1974 climatology calculated. These temperature anomalies were contoured for 0, 60, 120, 200, 300 and 400 meter depths, by month, in Figures 3.1-3.6, 5.1-5.6, 8.1-8.6, 11.1-11.6, 14.1-14.6, 17.1-17.6, 20.1-20.6, 23.1-23.6, and 25.1-25.6.

3. Kirwan/McNally Buoys

Several buoys drogued at 35 meters were deployed in the North Pacific ADS area from June, 1976 to the present. Because of attrition of old buoys and addition of new buoys, the number at any time varied from 12 to 26. Satellite fixes were obtained on each buoy several times a day; although the analyses of these data were not complete, monthly instantaneous buoy positions were available up to December, 1976. Monthly buoy displacement vectors have been plotted in Figures 6., 9., 12., 15., 18., and 21. Because the buoys were deployed in June, 1976, there are no buoy displacement data for that month.

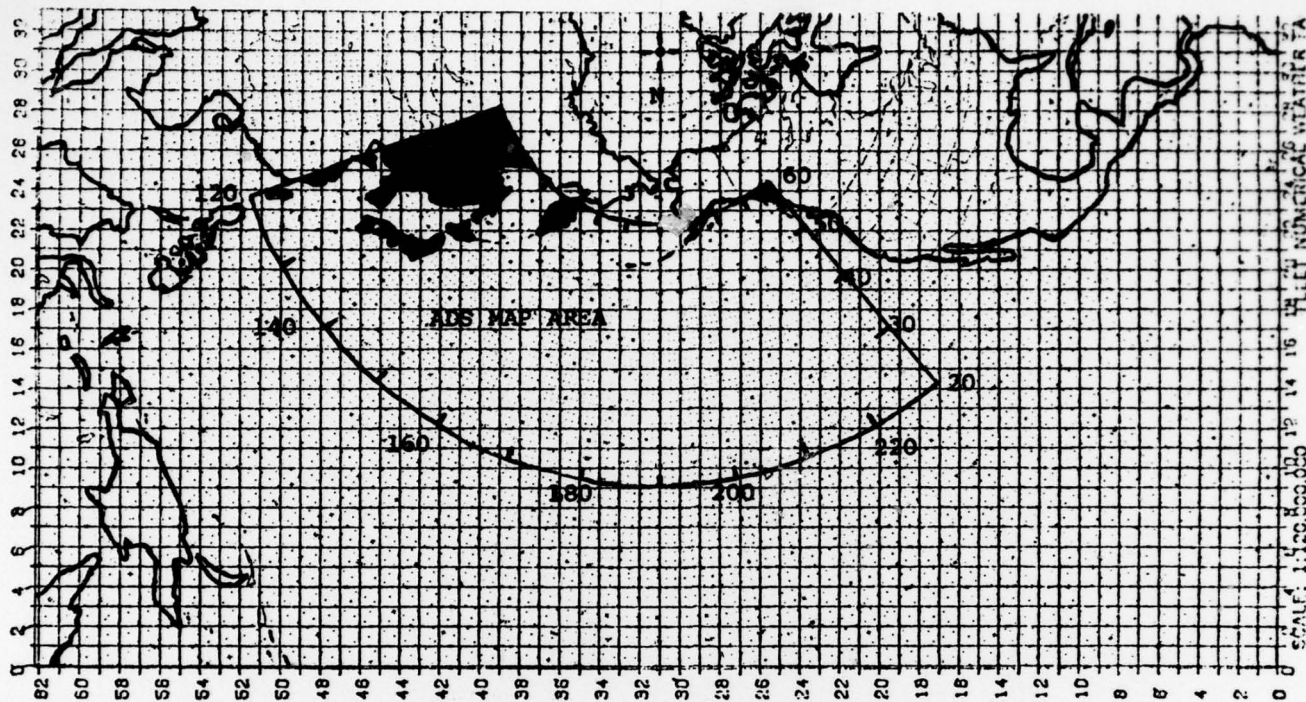


FIGURE 1. 33 x 63 field geographic coverage. The area of the ADS contour maps is as indicated. This map is a polar projection of the northern hemisphere.

WIND SPEED (M/SEC)

JUN 76

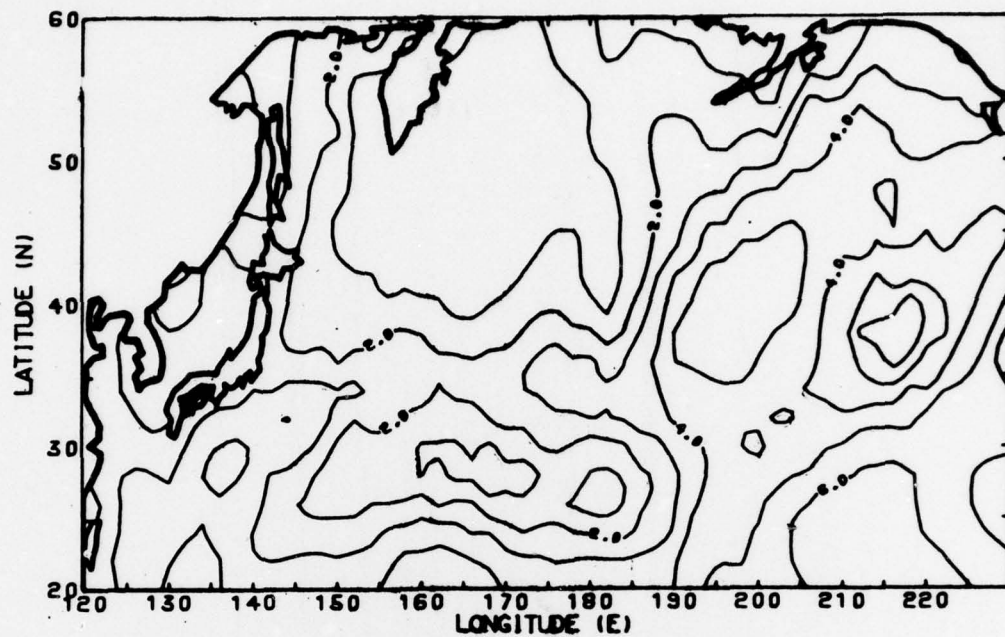


FIGURE 2.1

Absolute value of monthly mean vector wind velocities at 19.5 meters.
Contour intervals are 1 m/sec.

WIND DIRECTION

JUN 76

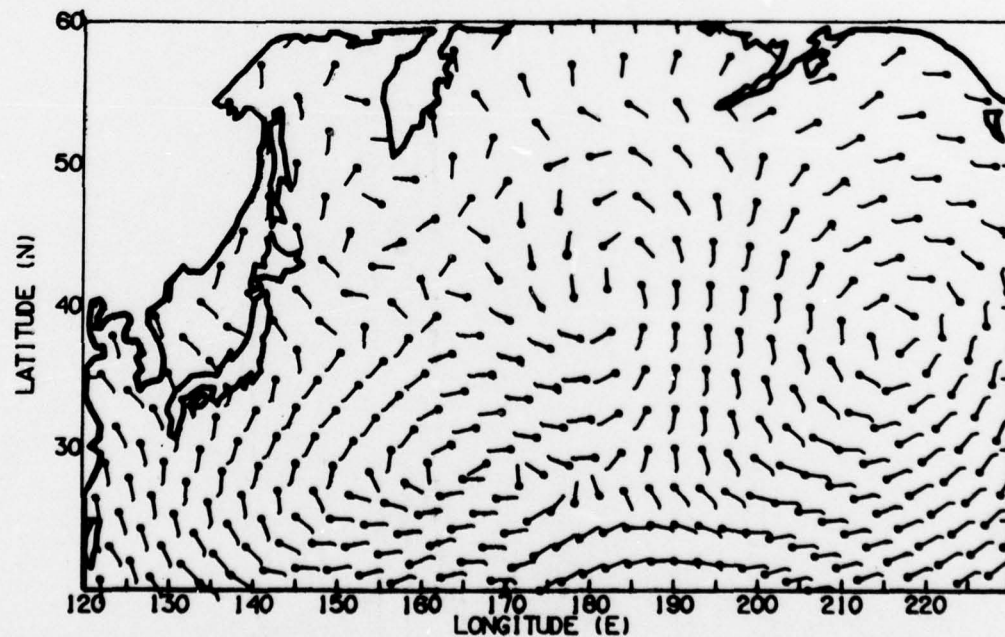


FIGURE 2.2

Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vane on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

WIND STRESS (DYNES/CM²)

JUN 76

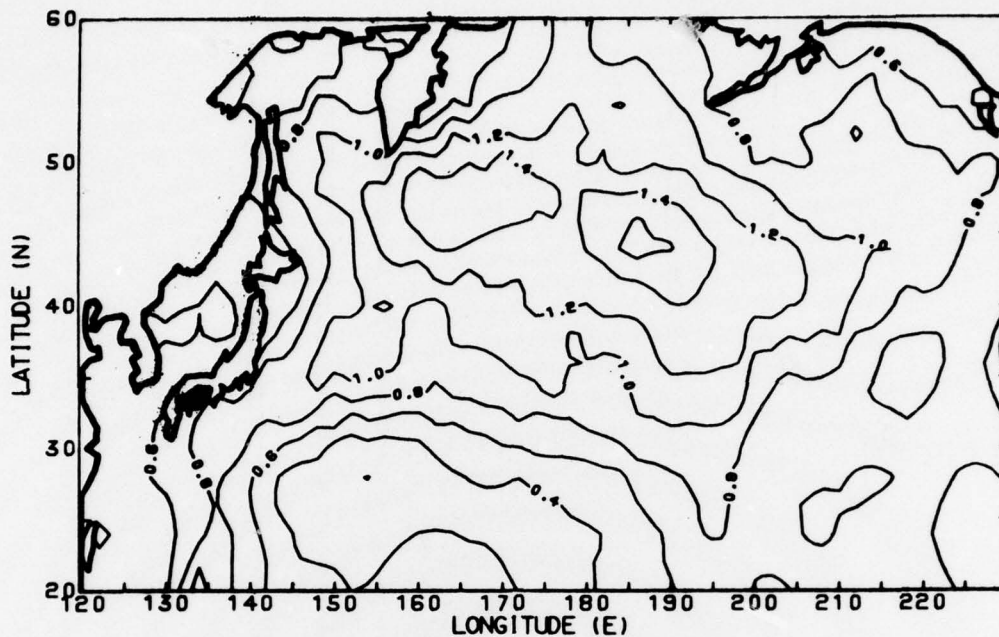


FIGURE 2.3 Monthly mean wind stress is the mean of 6-hourly wind stress at 10 meters calculated from FNWC wind data. Contour intervals are 0.2 dynes/cm².

CURL OF WIND STRESS (10⁻⁹ DYNES/CM³)

JUN 76

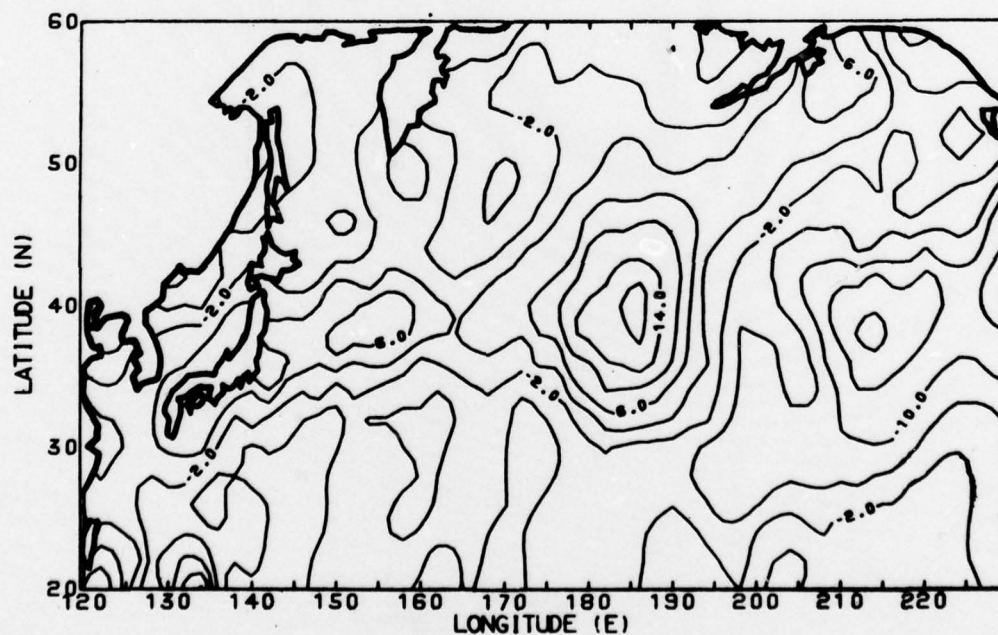


FIGURE 2.4 The vertical component of monthly mean wind stress curl is the mean of 6-hourly wind stress curl approximated by finite-differences from 6-hourly wind stresses at 10 meters. Isolines of zero curl are plotted heavily, and contour intervals are 4.0×10^{-9} dynes/cm³.

U STAR CUBED ((M/SEC)**3)

JUN 76

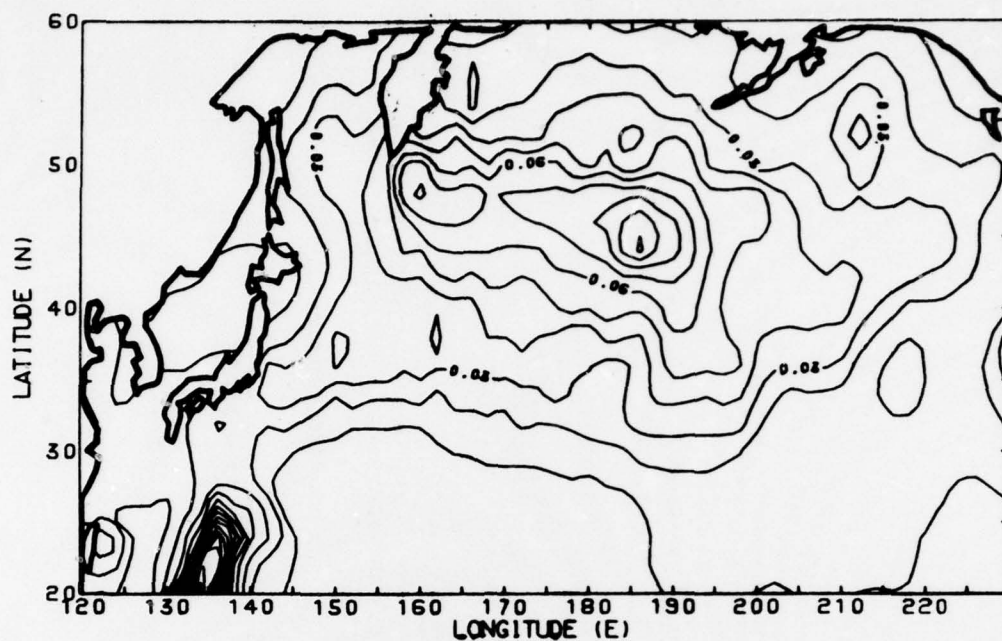


FIGURE 2.5 Monthly mean wind shear stress velocity cubed, U_*^3 is the mean of 6-hourly wind shear stress velocity cubed calculated from wind speed at 10 meters. Contour intervals are 0.01 (m/sec)³.

SEA SURFACE TEMPERATURE (DEG.C)

JUN 76

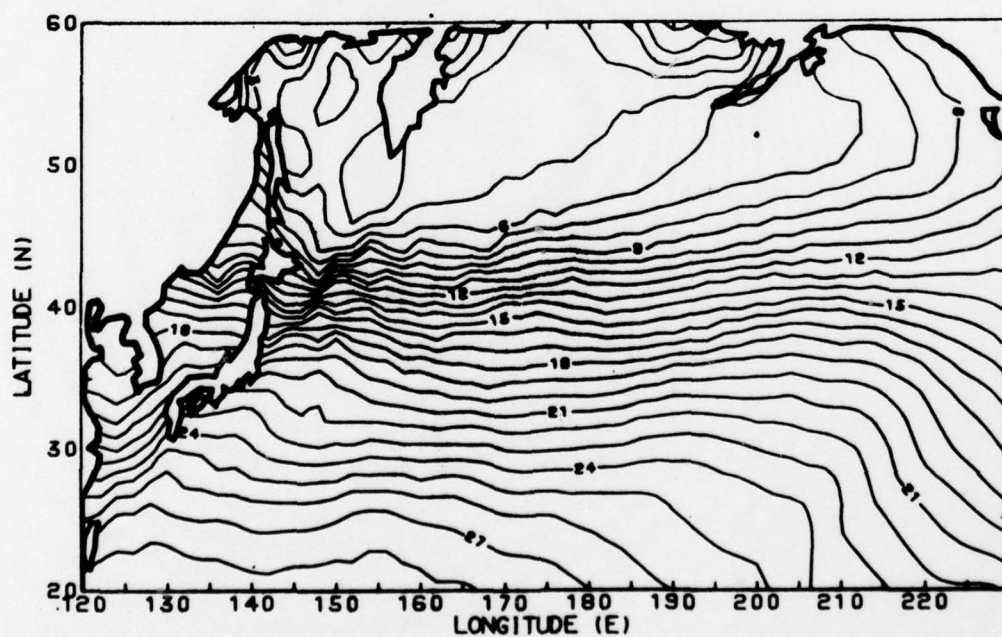


FIGURE 2.6 Monthly mean sea surface temperature is the mean of 12-hourly FNWC sea surface temperatures. Contour intervals are 1°C.

AIR TEMPERATURE (DEG. C) JUN 76

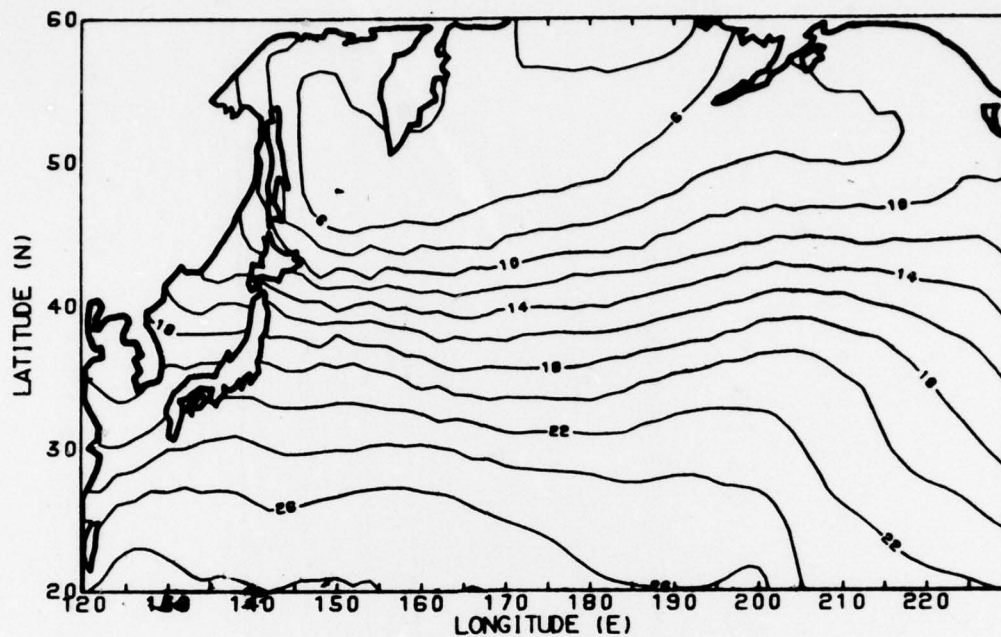


FIGURE 2.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) JUN 76

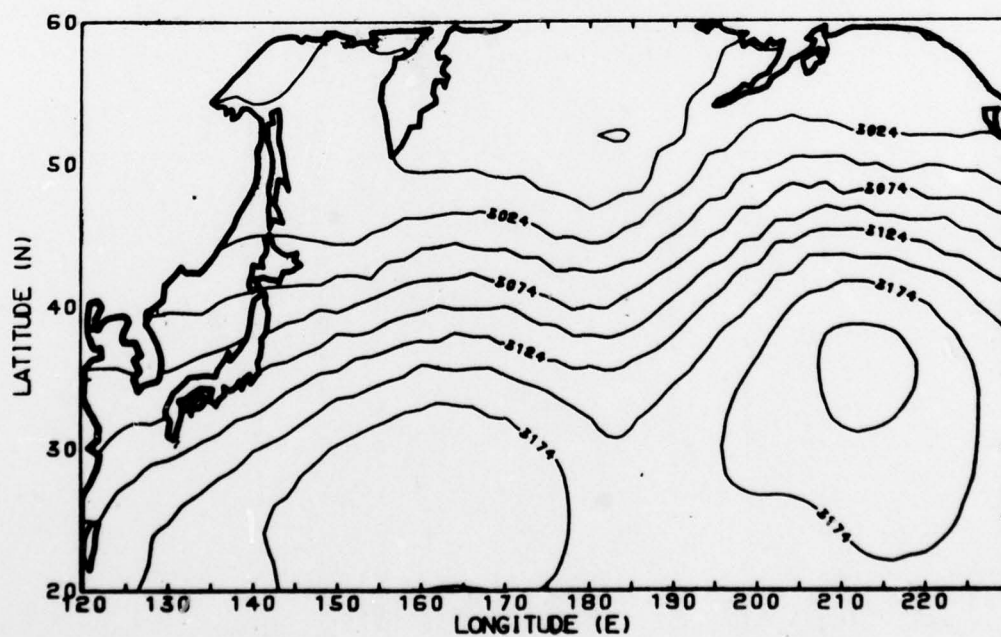


FIGURE 2.8 Monthly mean 700 mb height is the mean of 12-hourly FNWC 700 mb heights. Contour intervals are 25 meters.

VAPOR PRESSURE (MB) JUN 76

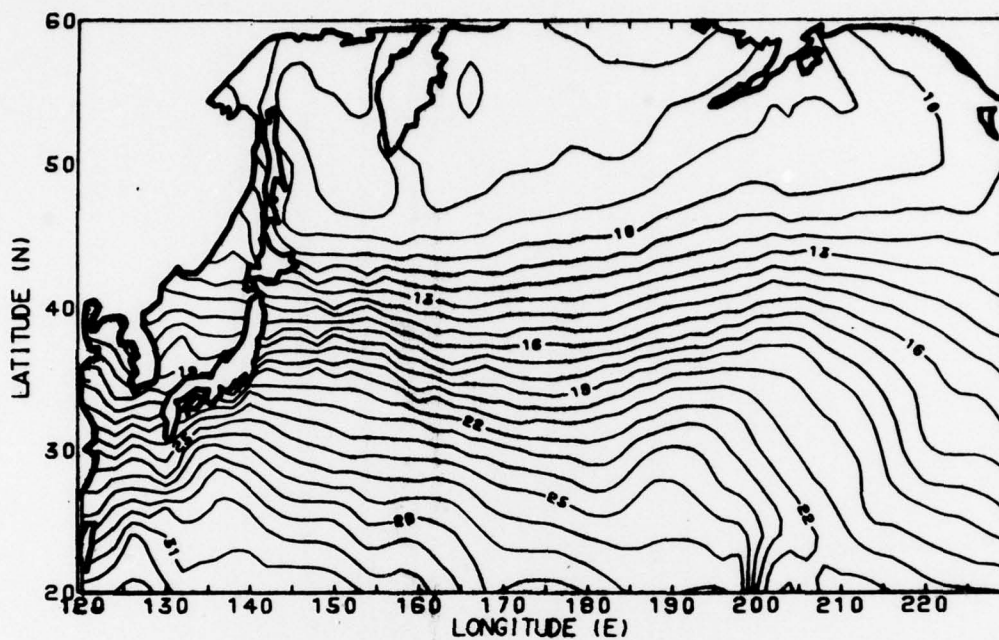


FIGURE 2.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM² SEC) JUN 76

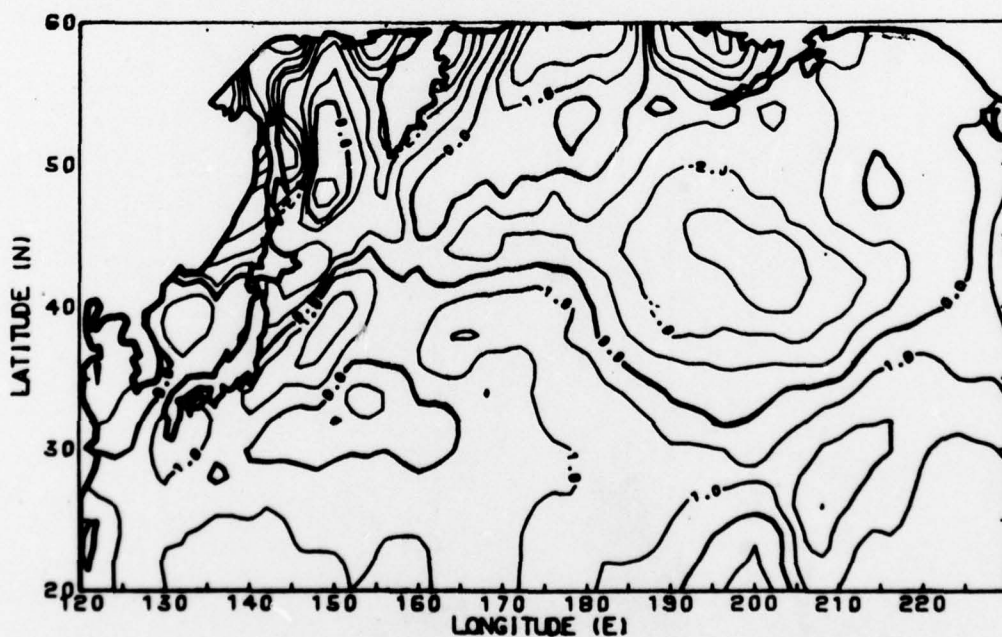


FIGURE 2.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm² sec.

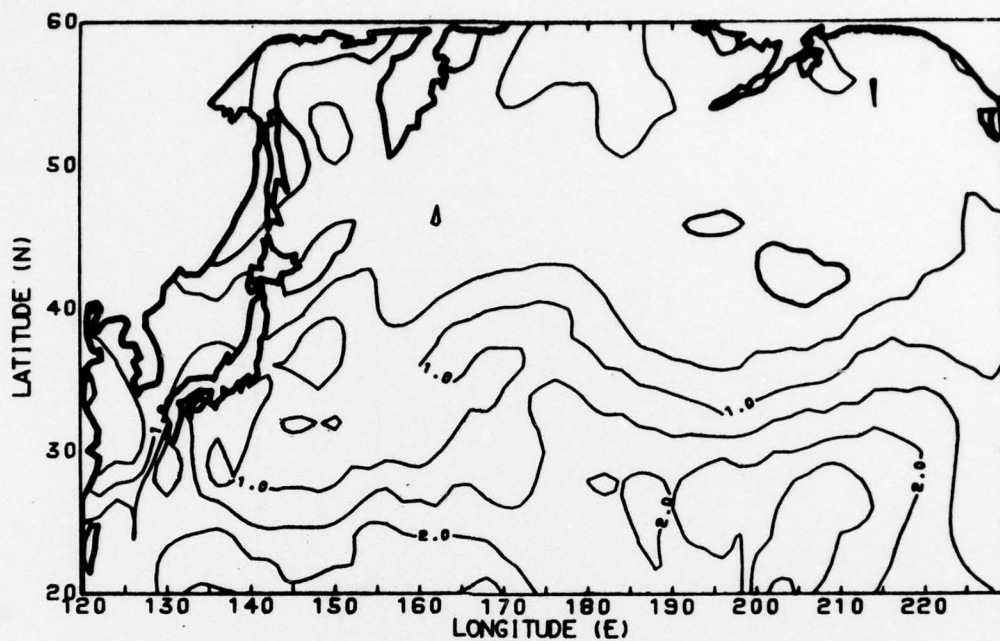


FIGURE 2.11

Monthly mean latent heat flux (ocean to atmosphere) is the mean of 12-hourly latent heat flux calculated from FNWC sea temperature, vapor pressure and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 0.5×10^{-3} cal/cm 2 sec.

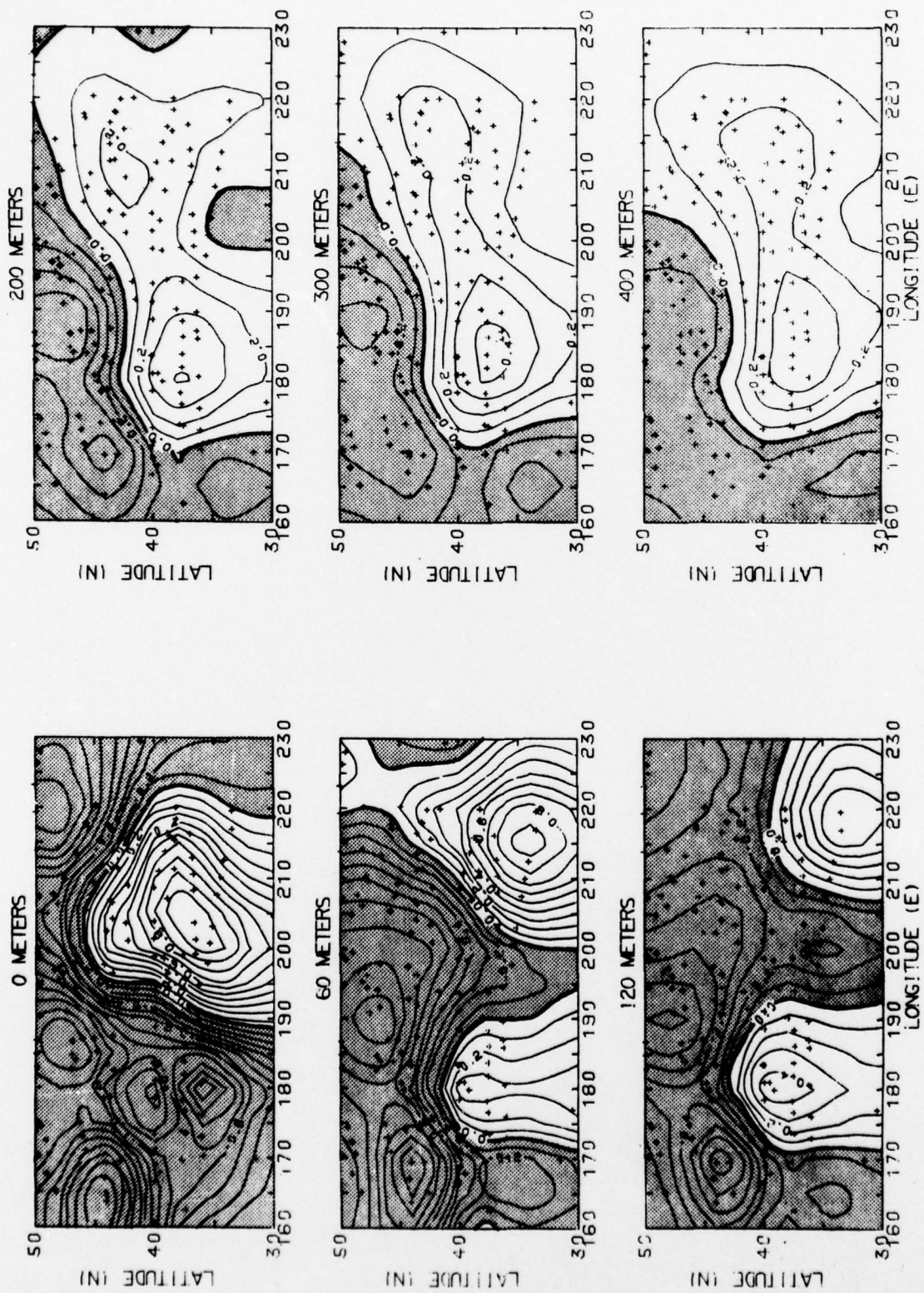


FIGURE 3. Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

WIND SPEED (M/SEC)

JUL 76

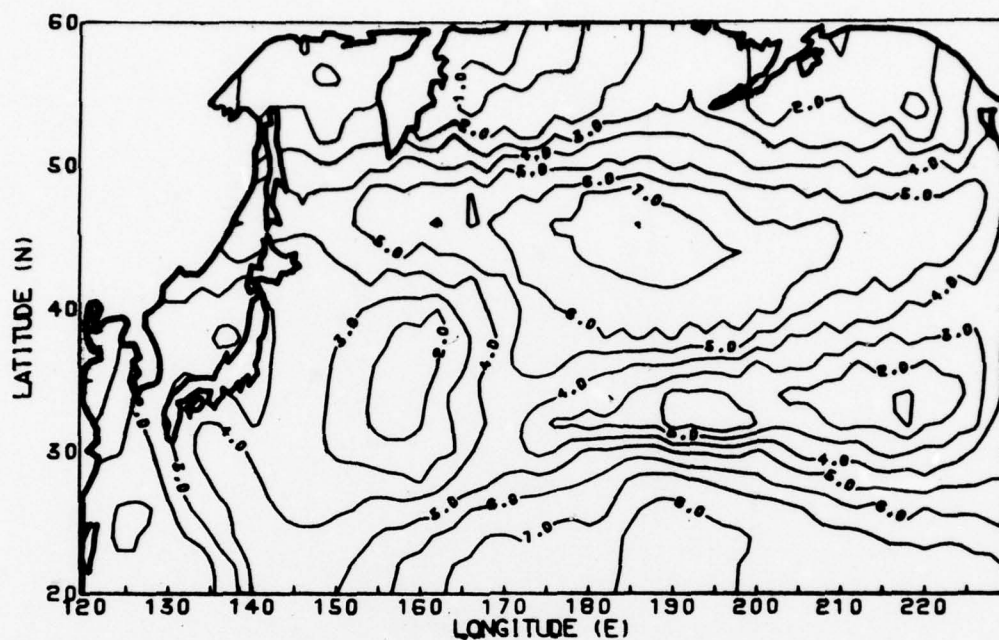


FIGURE 4.1 Absolute value of monthly mean vector wind velocities at 19.5 meters. Contour intervals are 1 m/sec.

WIND DIRECTION

JUL 76

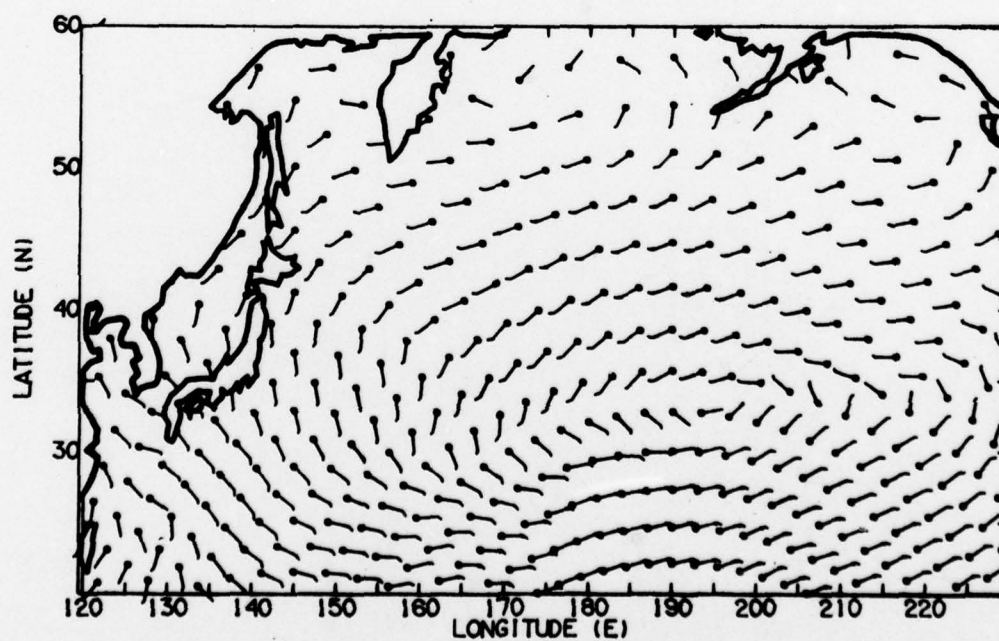


FIGURE 4.2 Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vanes on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

WIND STRESS (DYNES/CM²)

JUL 76

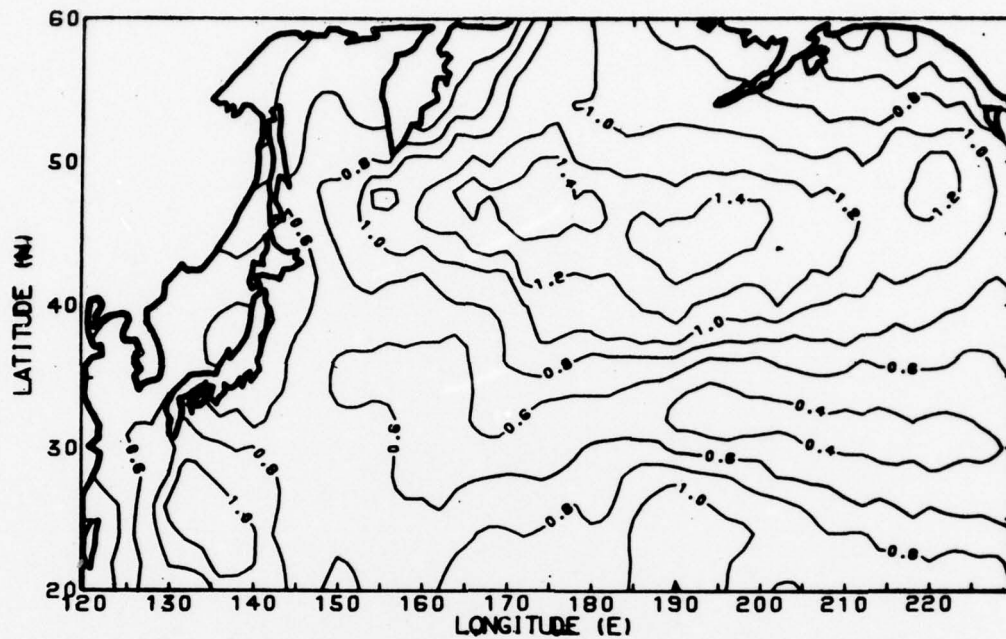


FIGURE 4.3 Monthly mean wind stress is the mean of 6-hourly wind stress at 10 meters calculated from FNWC wind data. Contour intervals are 0.2 dynes/cm².

CURL OF WIND STRESS (10^{-9} DYNES/CM³)

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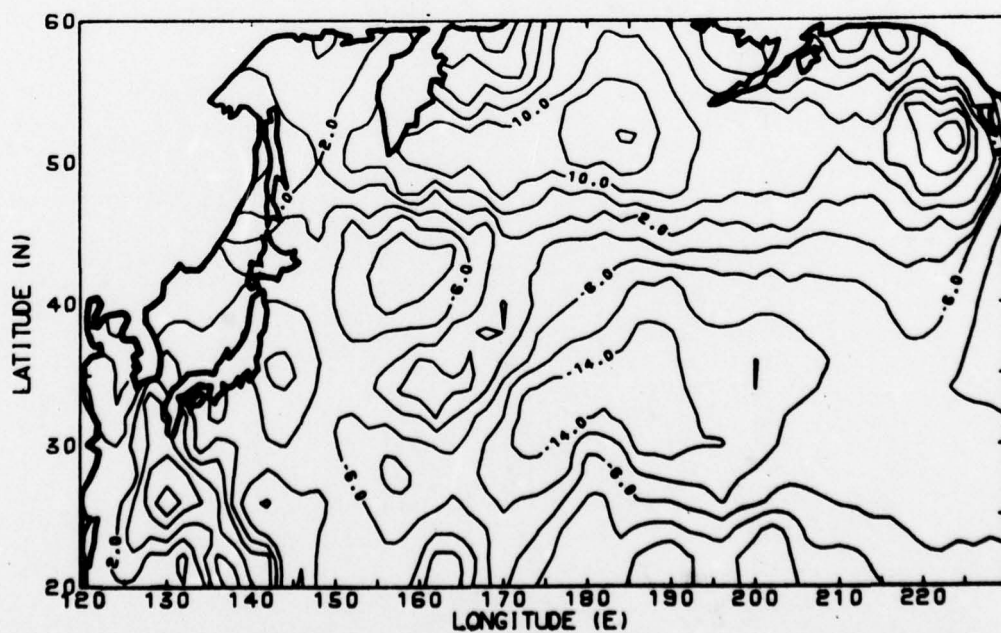


FIGURE 4.4 The vertical component of monthly mean wind stress curl is the mean of 6-hourly wind stress curl approximated by finite-differences from 6-hourly wind stresses at 10 meters. Isolines of zero curl are plotted heavily, and contour intervals are 4.0×10^{-9} dynes/cm³.

U STAR CUBED ((M/SEC)³)

JUL 76

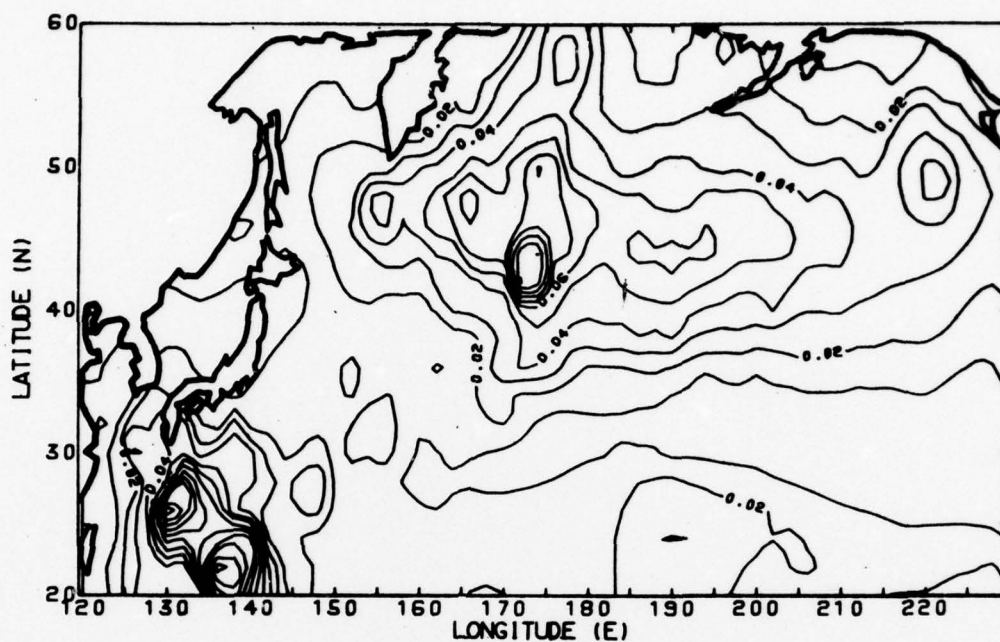


FIGURE 4.5 Monthly mean wind shear stress velocity cubed, U_*^3 is the mean of 6-hourly wind shear stress velocity cubed calculated from wind speed at 10 meters. Contour intervals are 0.02 (m/sec)³.

SEA SURFACE TEMPERATURE (DEG.C)

JUL 76

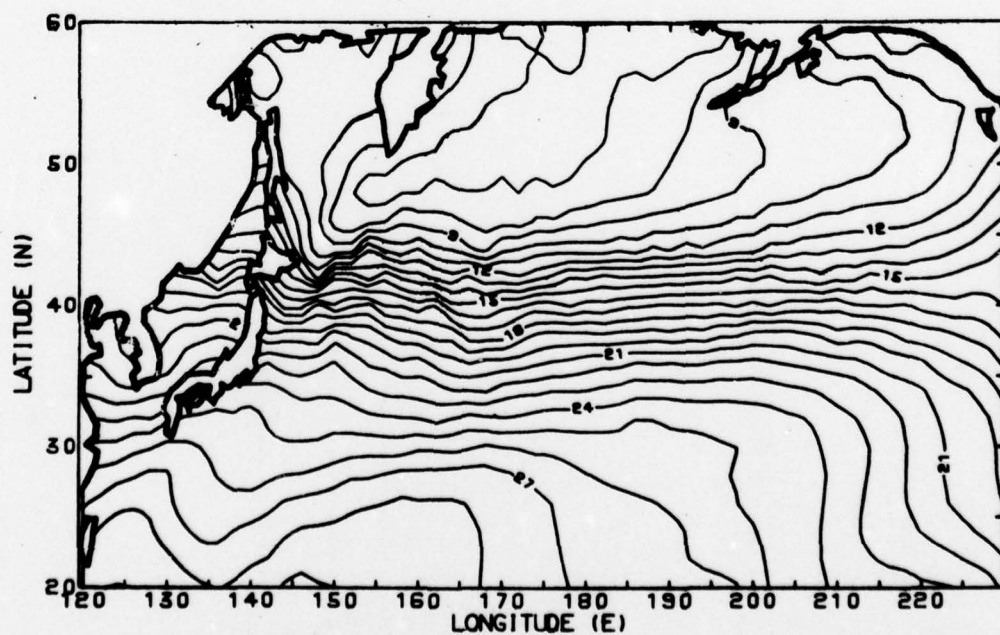


FIGURE 4.6 Monthly mean sea surface temperature is the mean of 12-hourly FNWC sea surface temperatures. Contour intervals are 1°C.

AIR TEMPERATURE (DEG. C) JUL 76

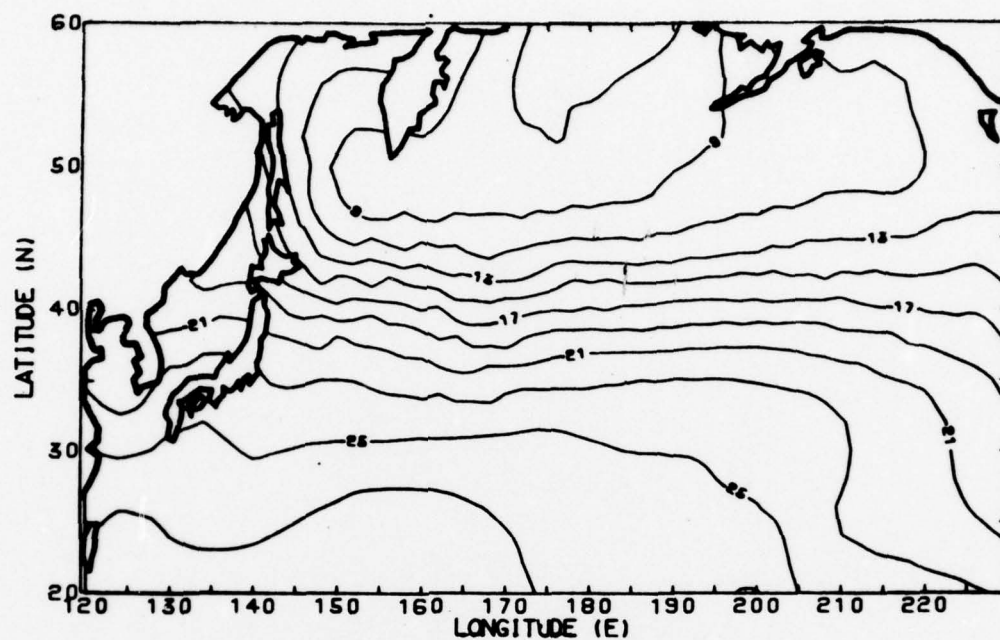


FIGURE 4.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) JUL 76

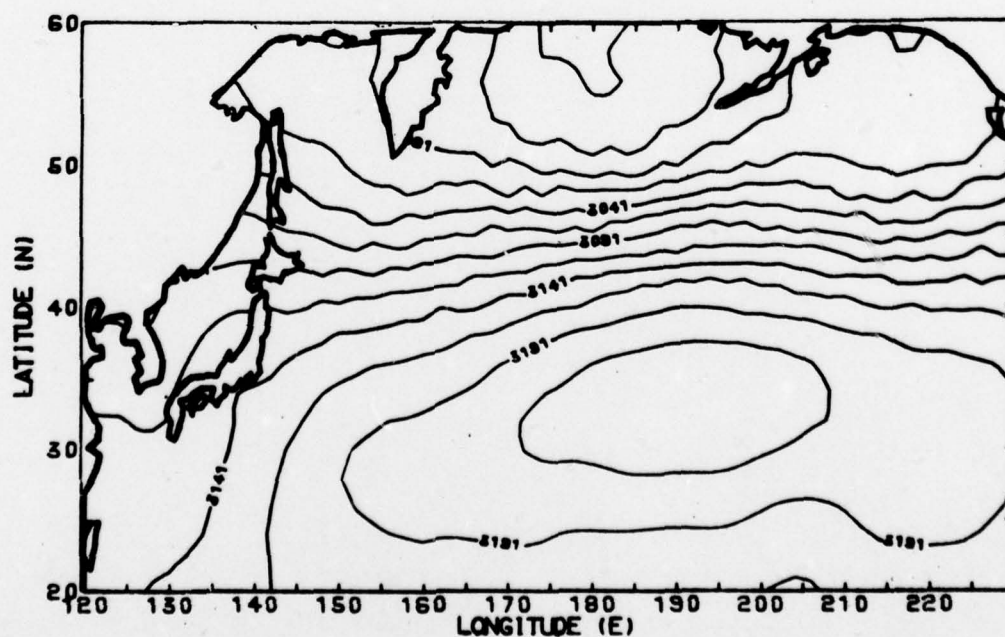


FIGURE 4.8 Monthly mean 700 mb height is the mean of 12-hourly FNWC 700 mb heights. Contour intervals are 25 meters.

VAPOR PRESSURE (MB) JUL 76

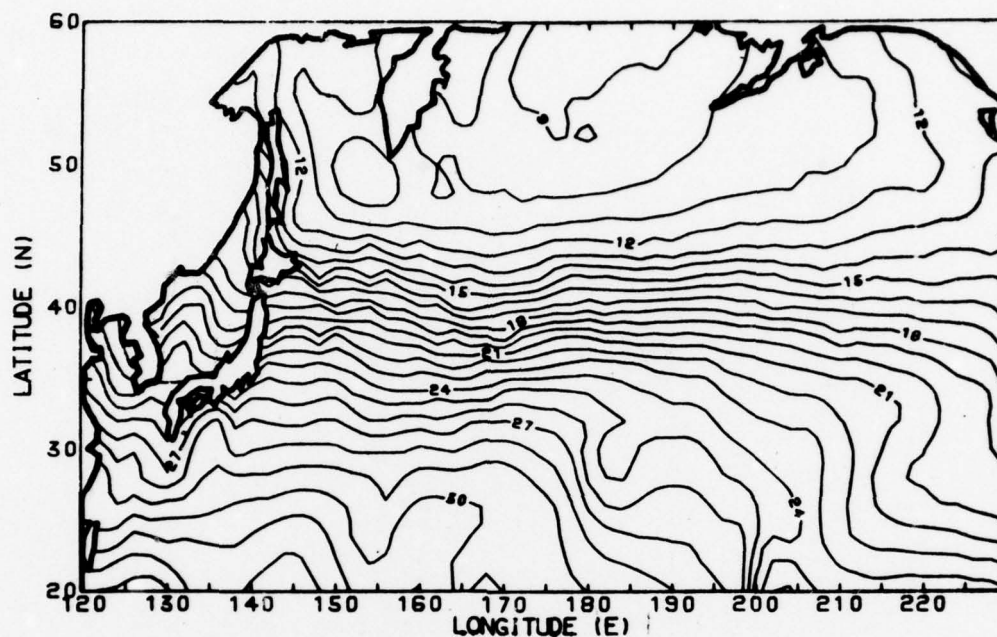


FIGURE 4.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM² SEC) JUL 76

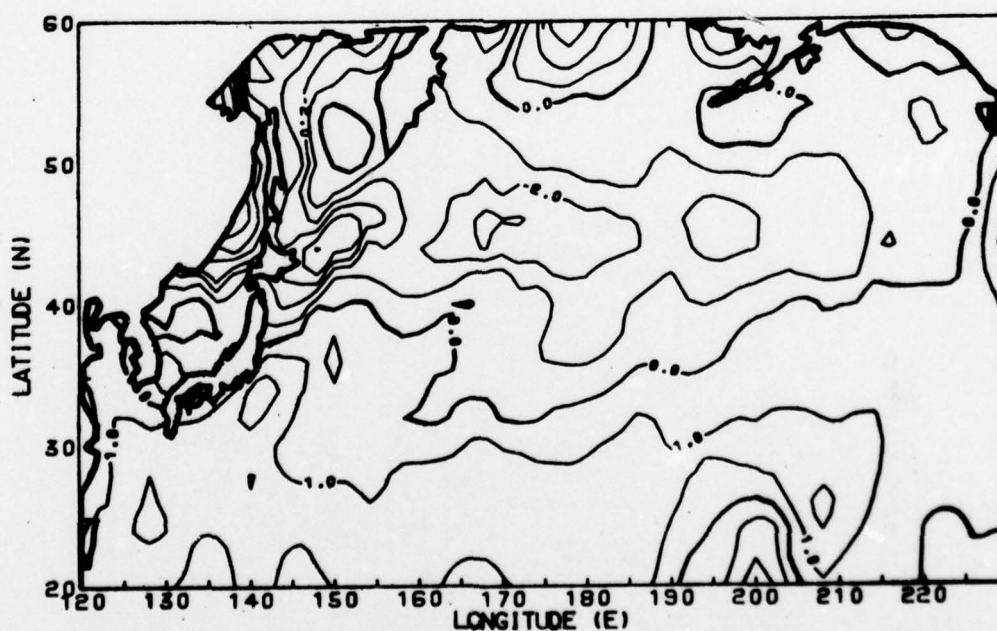


FIGURE 4.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm² sec.

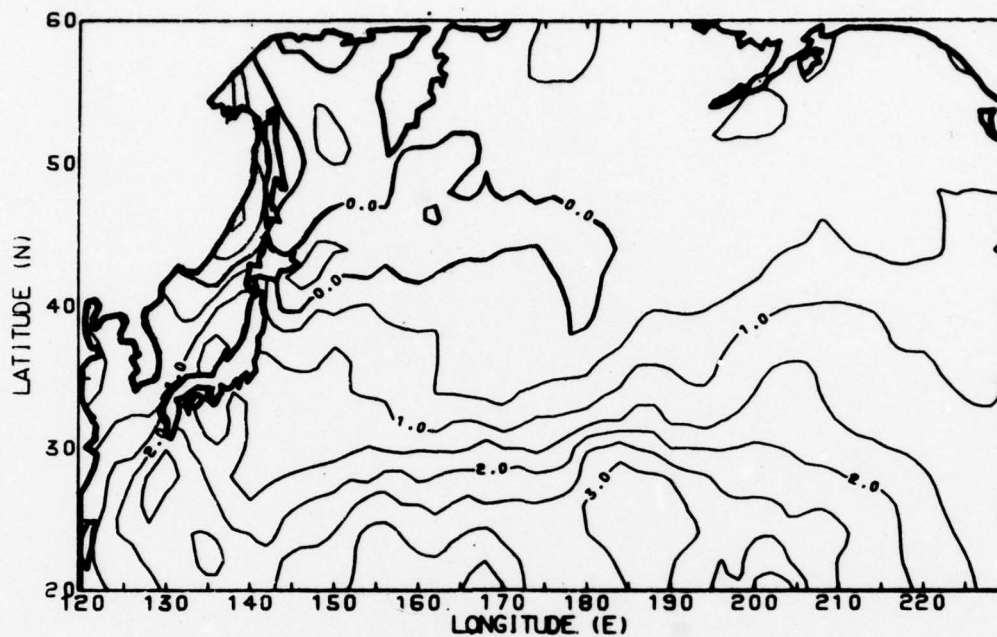


FIGURE 4.11

Monthly mean latent heat flux (ocean to atmosphere) is the mean of 12-hourly latent heat flux calculated from FNWC sea temperature, vapor pressure and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 0.5×10^{-3} cal/cm 2 sec.

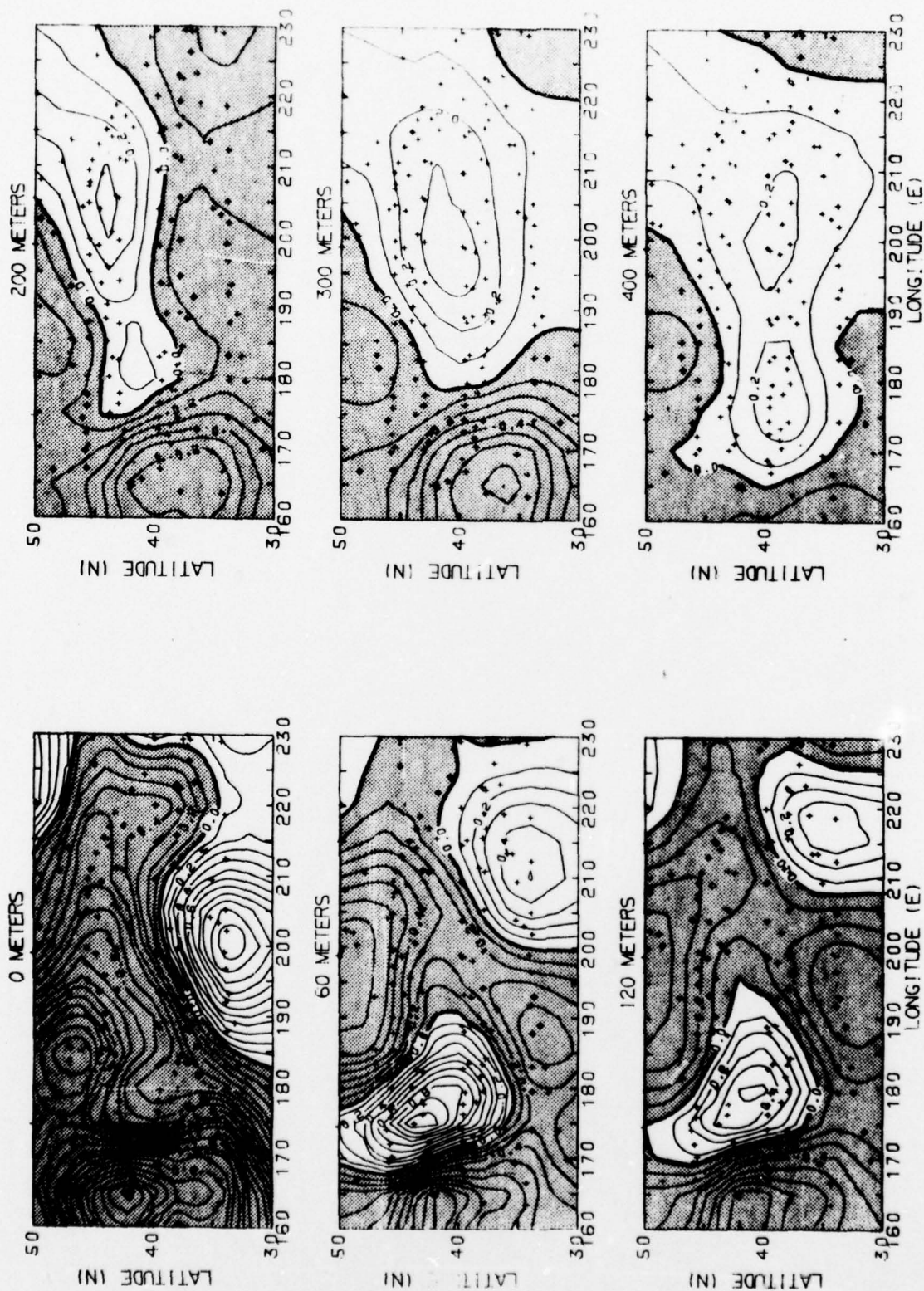
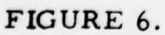


FIGURE 5. Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.



Monthly buoy displacement vectors. Vectors are drawn from start point at beginning of month to terminal point at end of month.

WIND SPEED (M/SEC)

AUG 76

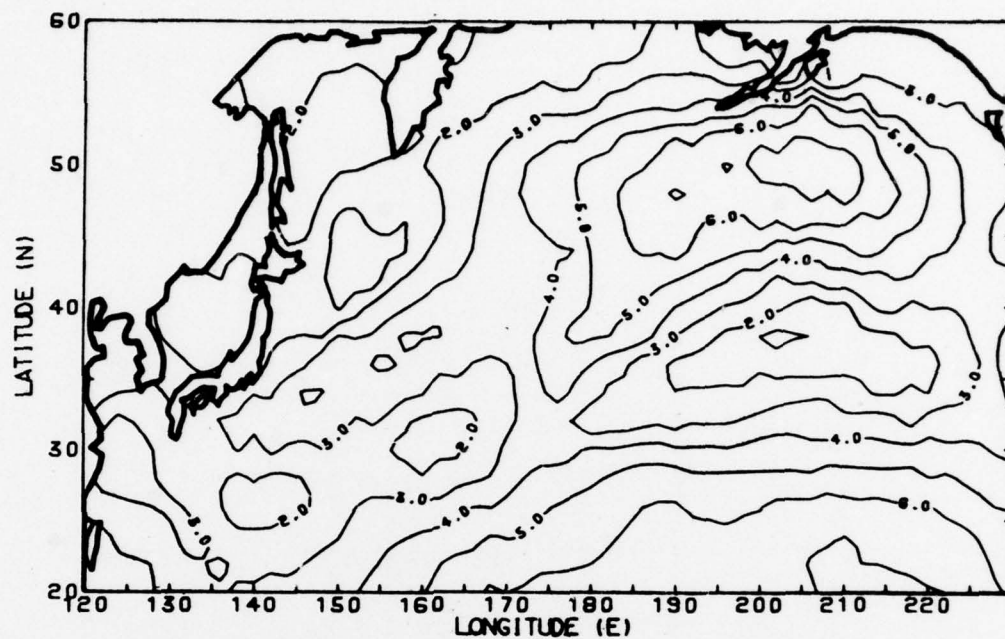


FIGURE 7.1 Absolute value of monthly mean vector wind velocities at 19.5 meters. Contour intervals are 1 m/sec.

WIND DIRECTION

AUG 76

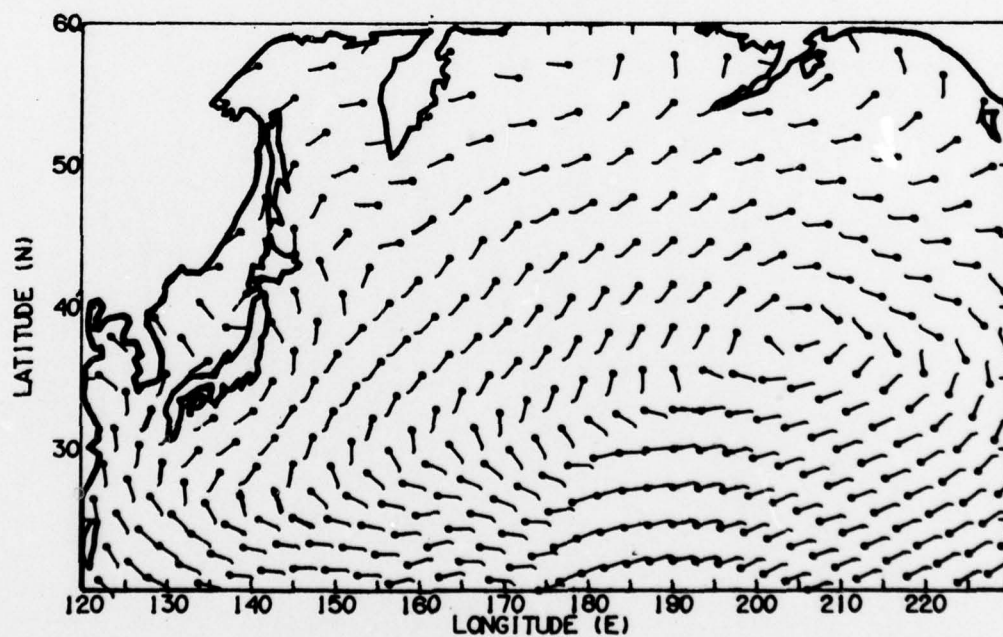
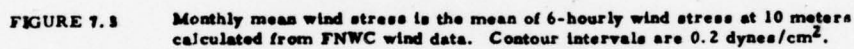
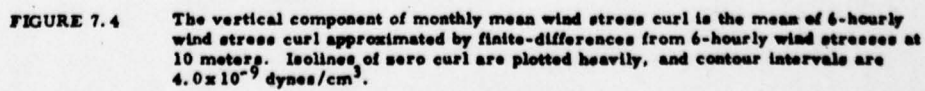


FIGURE 7.2 Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vanes on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

AUG 76



AUG 76



U STAR CUBED ((M/SEC)**3)

AUG 76

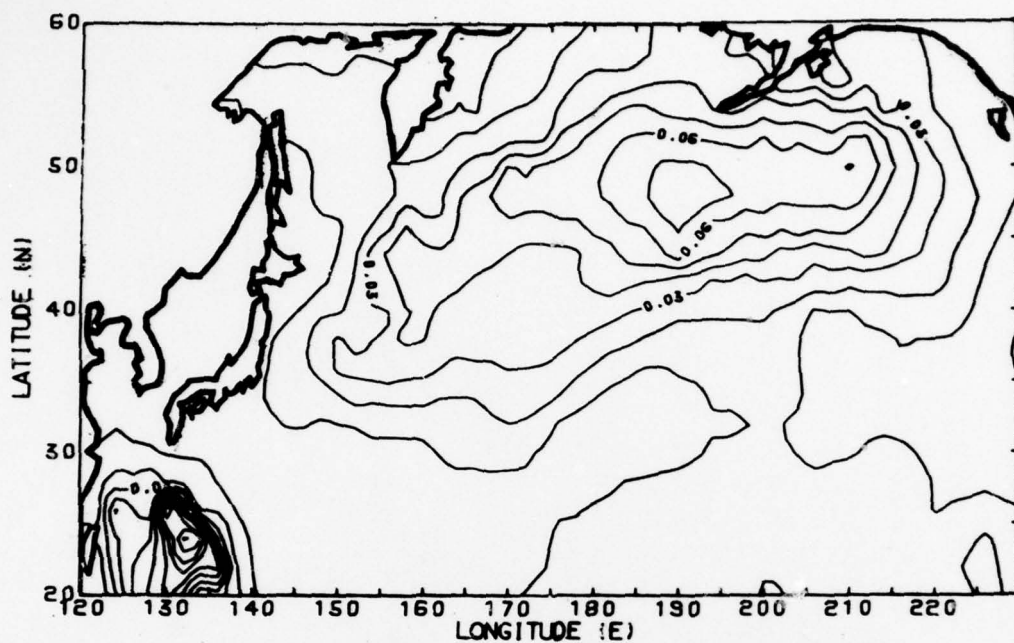


FIGURE 7.5 Monthly mean wind shear stress velocity cubed, U_*^3 is the mean of 6-hourly wind shear stress velocity cubed calculated from wind speed at 10 meters. Contour intervals are 0.01 (m/sec)^3 .

SEA SURFACE TEMPERATURE (DEG.C)

AUG 76

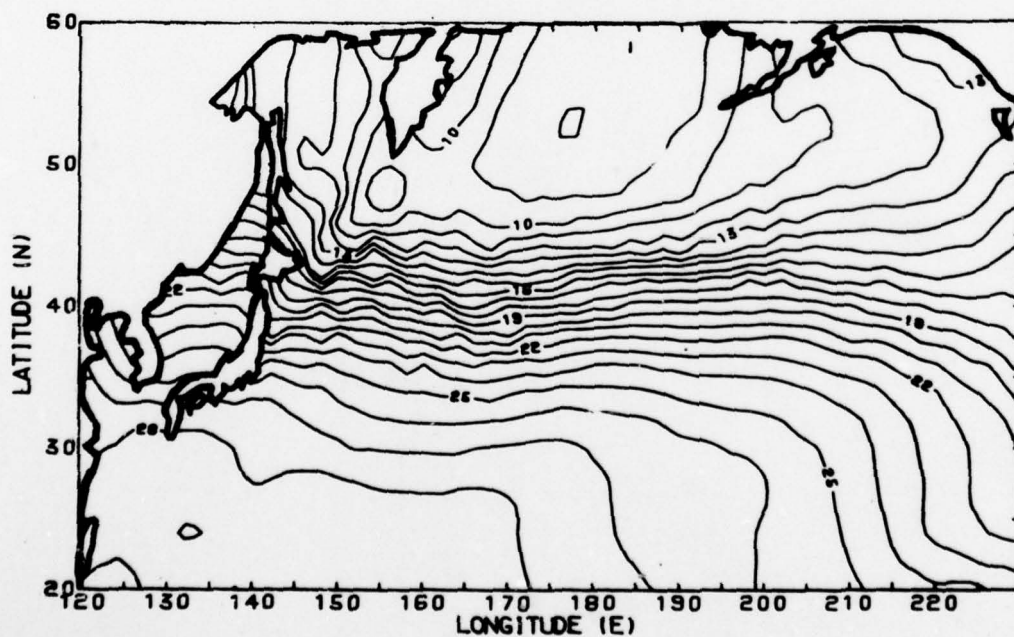


FIGURE 7.6 Monthly mean sea surface temperature is the mean of 12-hourly FNWC sea surface temperatures. Contour intervals are 1°C .

AUG 76

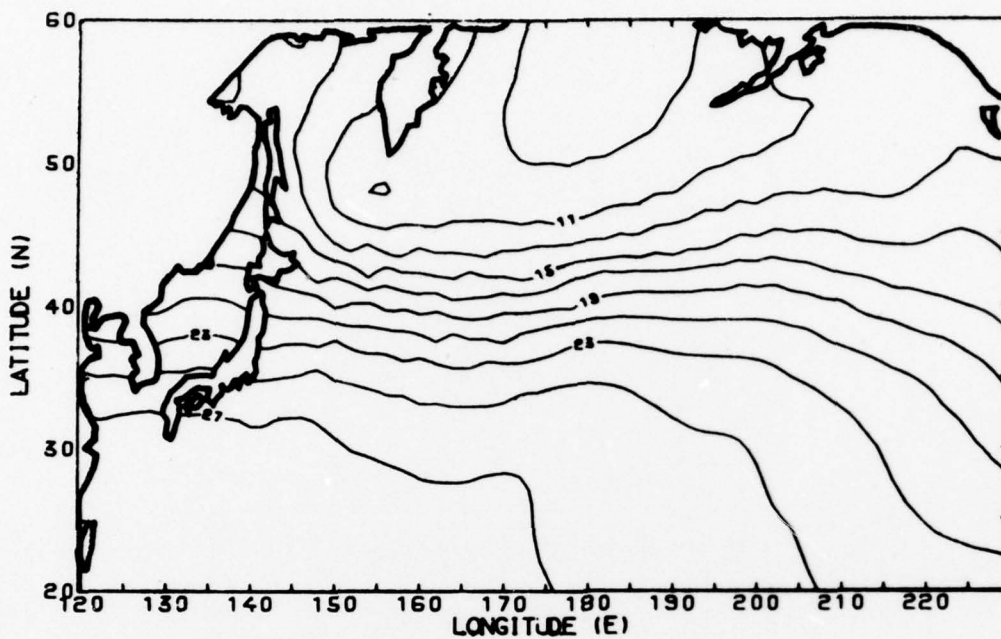


FIGURE 7.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

AUG 76

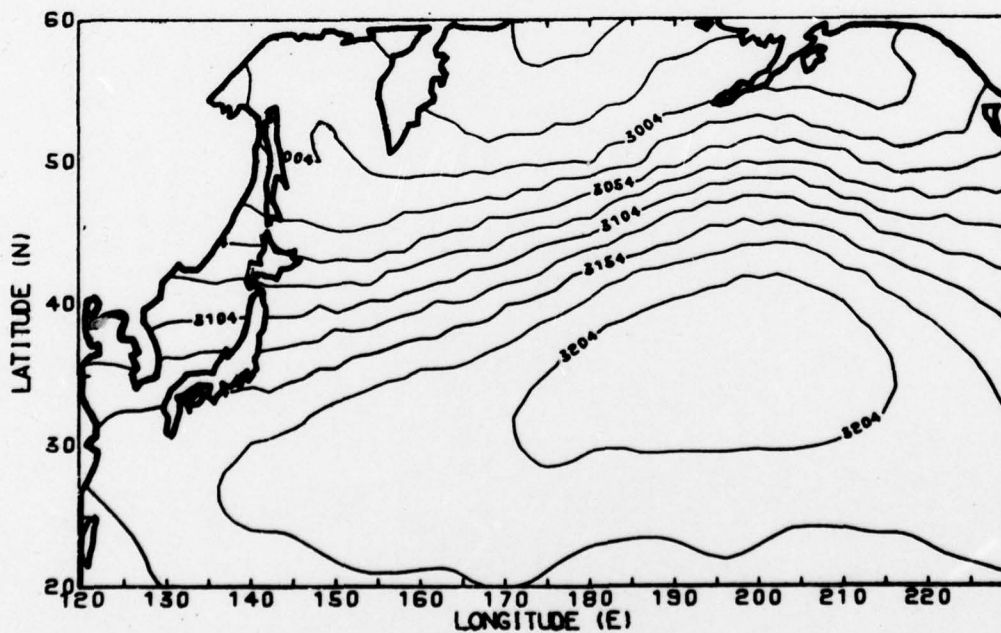


FIGURE 7.8 Monthly mean 700 mb height is the mean of 12-hourly FNWC 700 mb heights. Contour intervals are 25 meters.

VAPOR PRESSURE (MB)

AUG 76

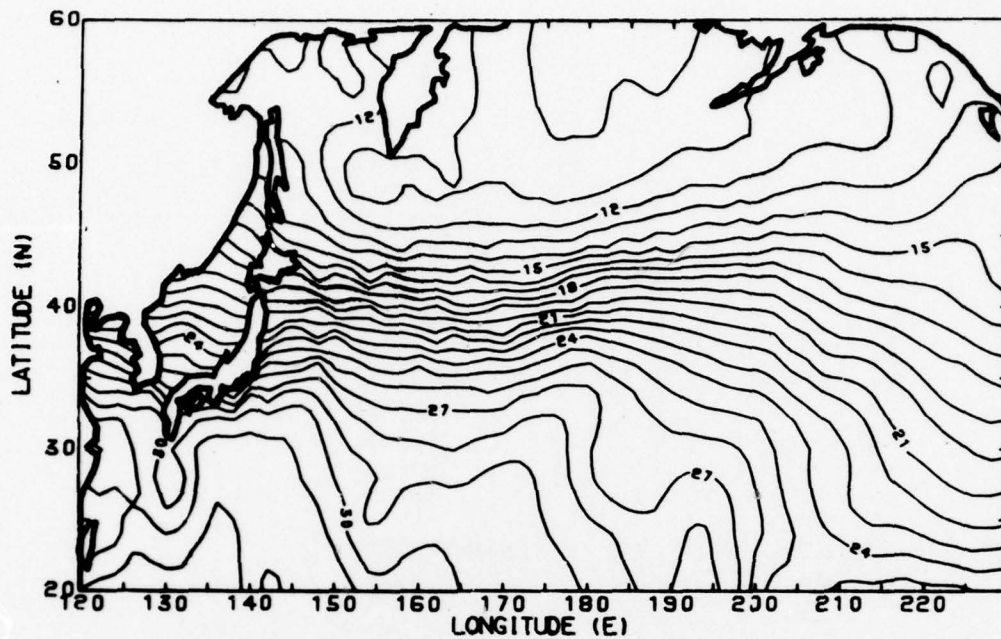


FIGURE 7.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM² SEC)

AUG 76

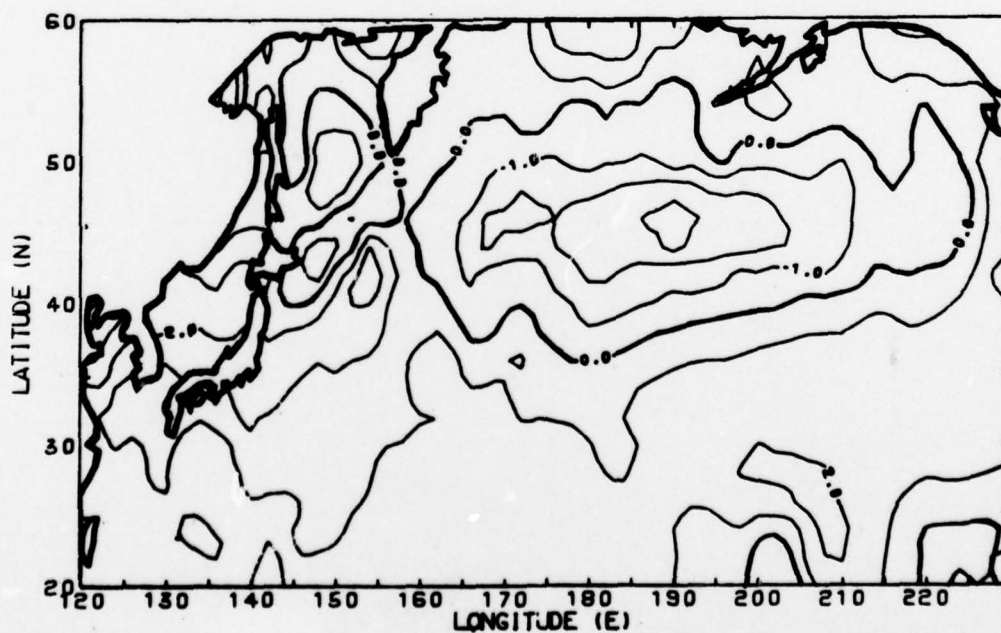


FIGURE 7.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm² sec.

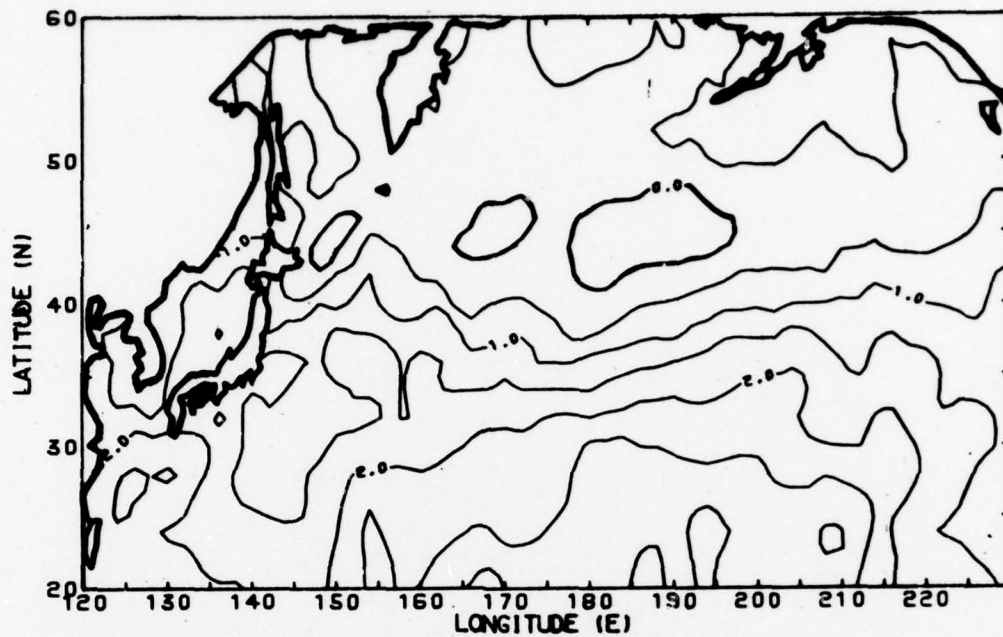


FIGURE 7.11 Monthly mean latent heat flux (ocean to atmosphere) is the mean of 12-hourly latent heat flux calculated from FNWC sea temperature, vapor pressure and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 0.5×10^{-3} cal/cm 2 sec.

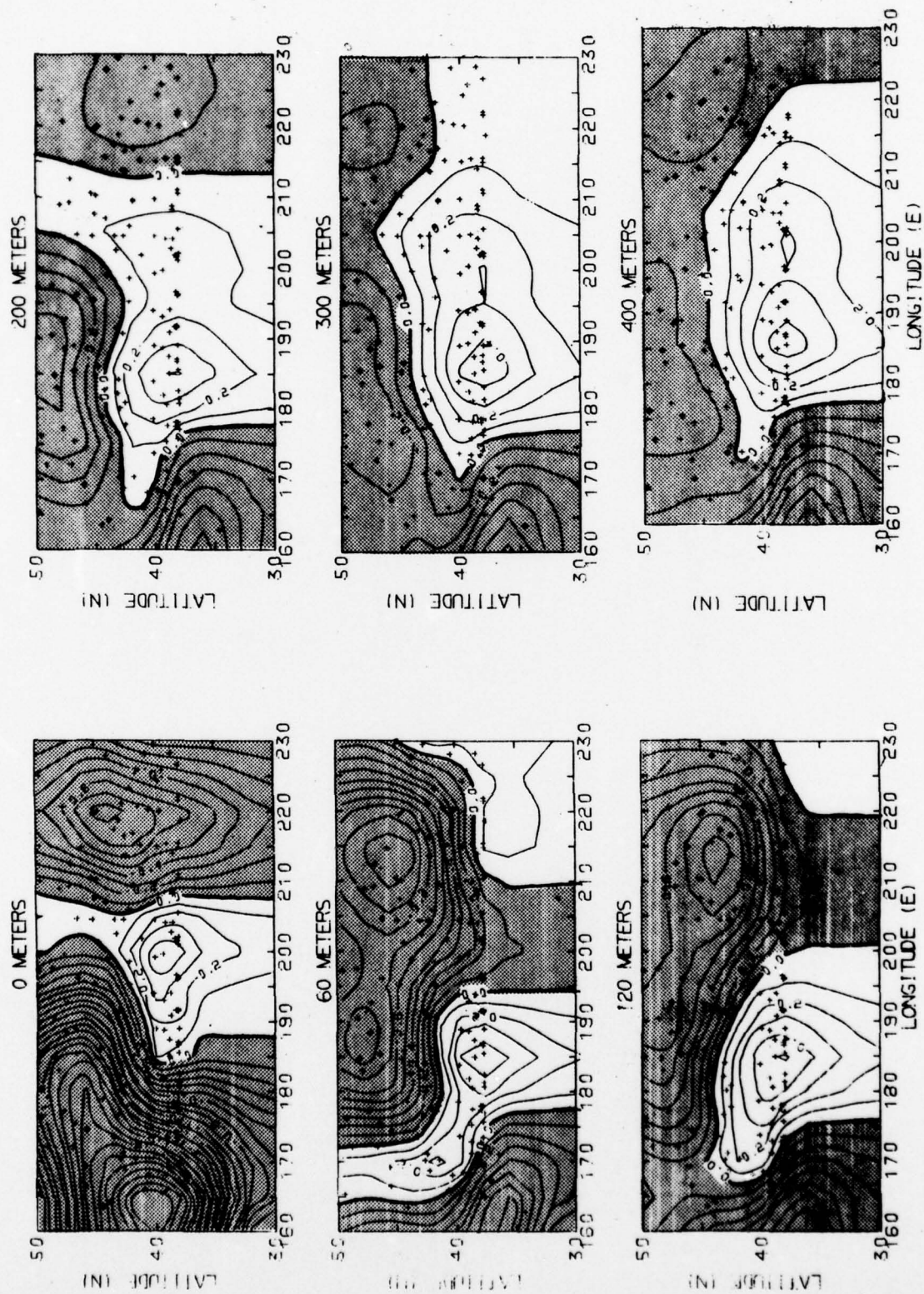


FIGURE 8. Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

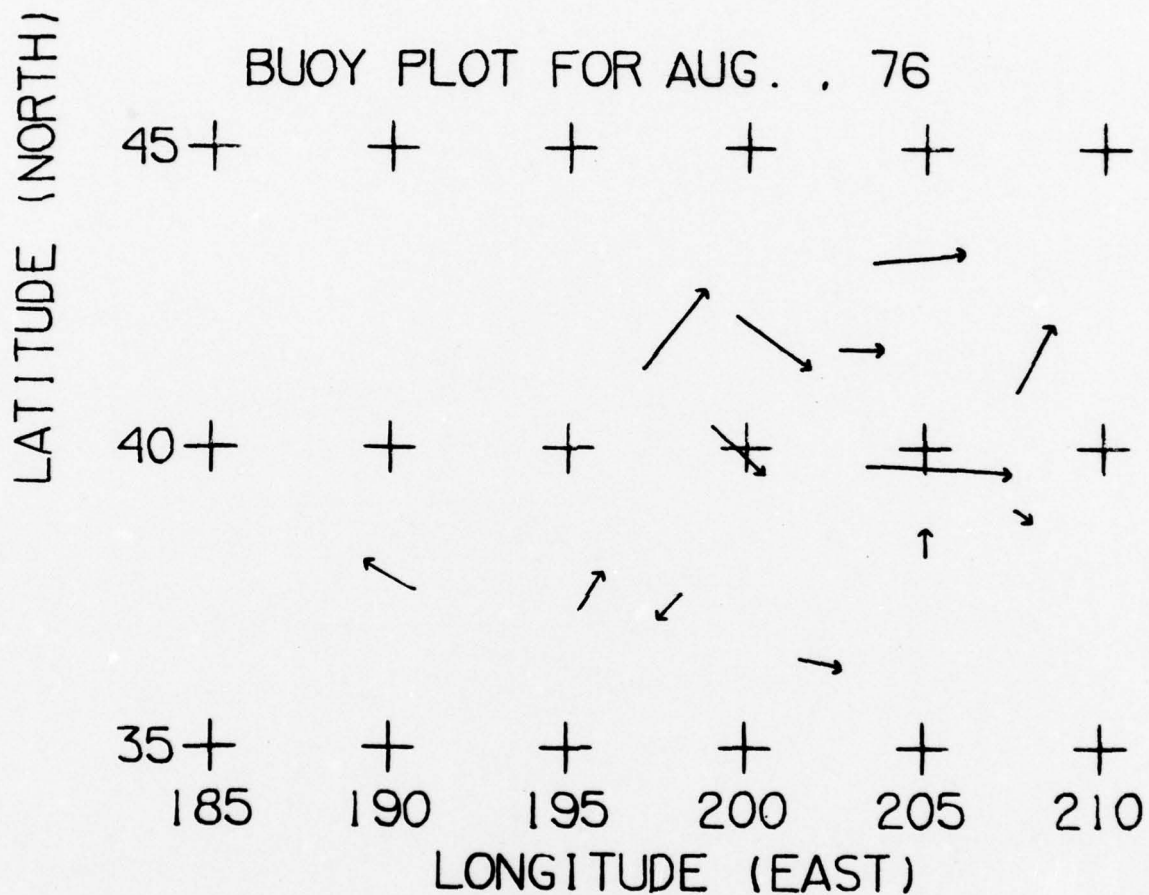


FIGURE 9.

Monthly buoy displacement vectors. Vectors are drawn from start point at beginning of month to terminal point at end of month.

WIND SPEED (M/SEC)

SEP 76

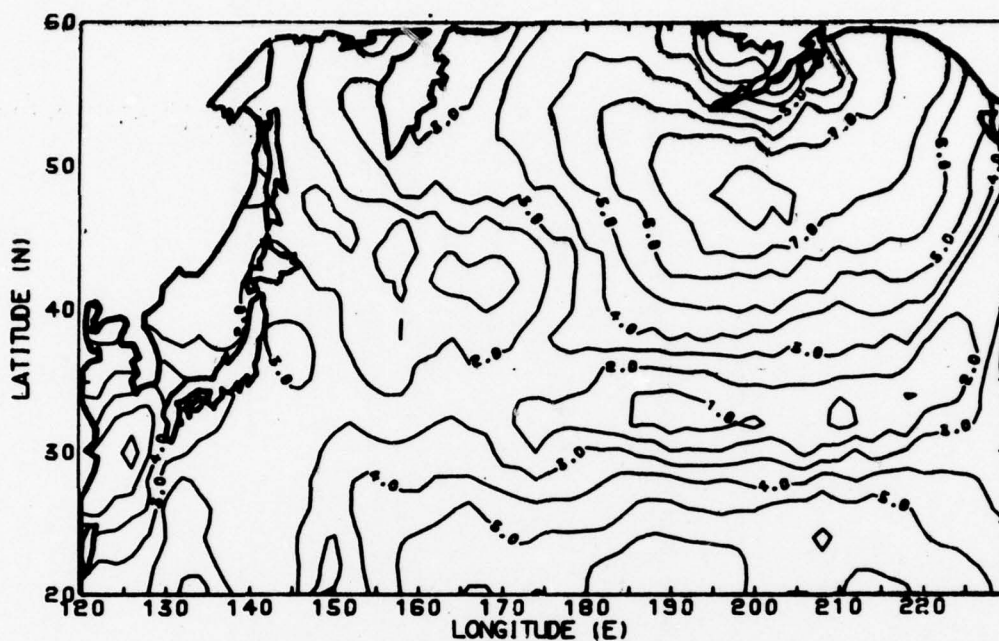


FIGURE 10.1 Absolute value of monthly mean vector wind velocities at 19.5 meters. Contour intervals are 1 m/sec.

WIND DIRECTION

SEP 76

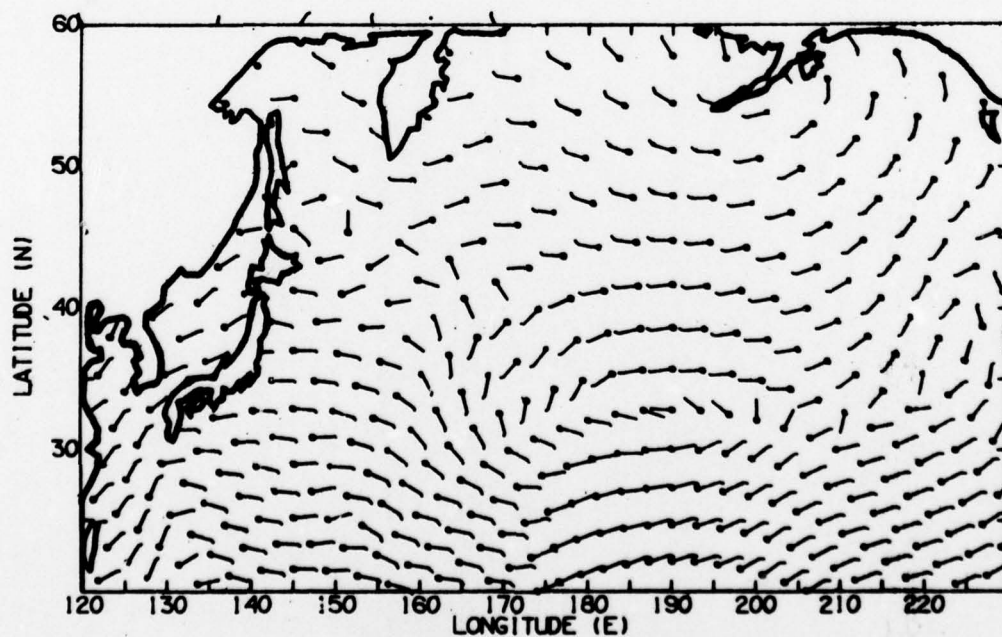


FIGURE 10.2 Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vanes on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

WIND STRESS (DYNES/CM²)

SEP 76

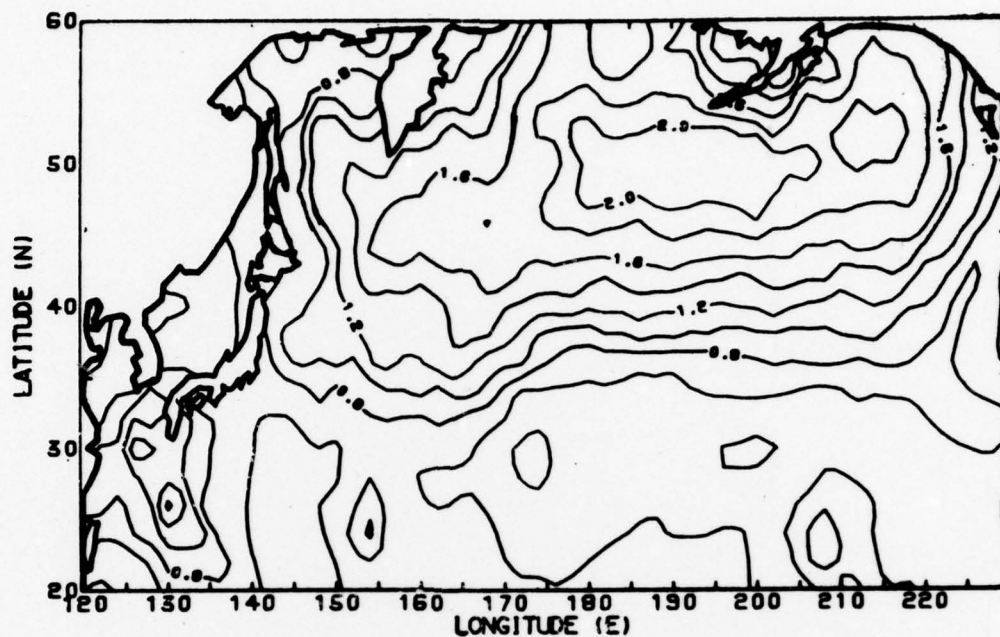


FIGURE 10.3 Monthly mean wind stress is the mean of 6-hourly wind stress at 10 meters calculated from FNWC wind data. Contour intervals are 0.2 dynes/cm².

CURL OF WIND STRESS (10^{-9} DYNES/CM³)

SEP 76

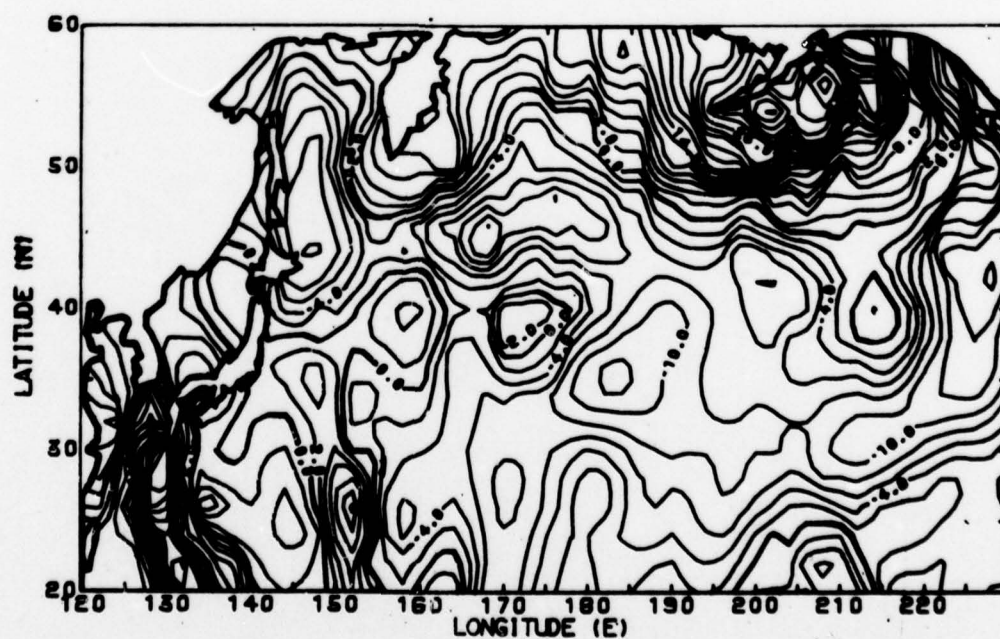


FIGURE 10.4 The vertical component of monthly mean wind stress curl is the mean of 6-hourly wind stress curl approximated by finite-differences from 6-hourly wind stresses at 10 meters. Isolines of zero curl are plotted hourly, and contour intervals are 4.0×10^{-9} dynes/cm³.

U STAR CUBED ((M/SEC)**3)

SEP 76

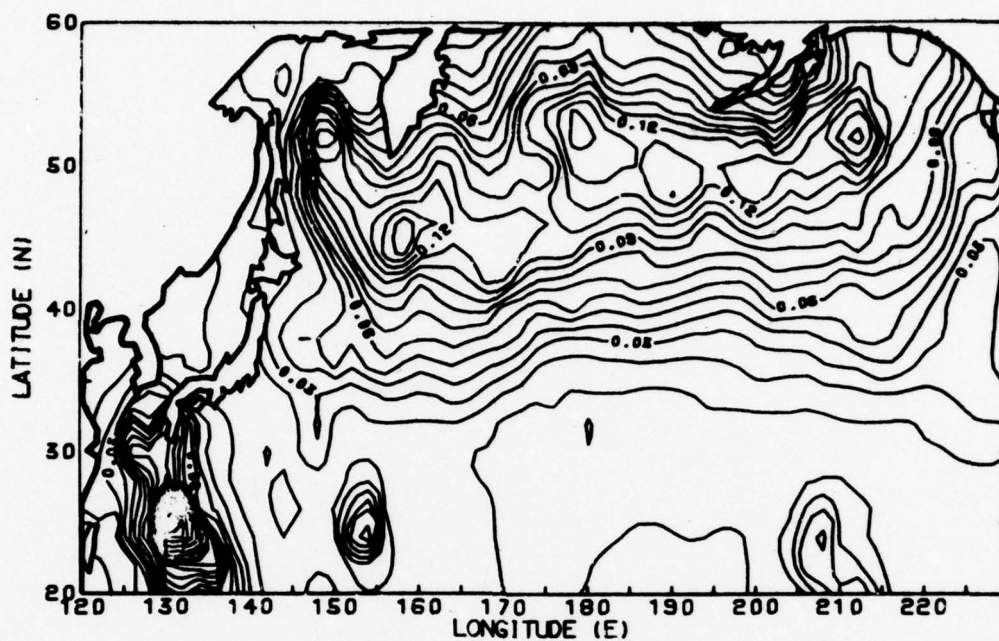


FIGURE 10.5 Monthly mean wind shear stress velocity cubed, U_*^3 is the mean of 6-hourly wind shear stress velocity cubed calculated from wind speed at 10 meters. Contour intervals are 0.05 (m/sec)^3 .

SEA SURFACE TEMPERATURE (DEG.C)

SEP 76

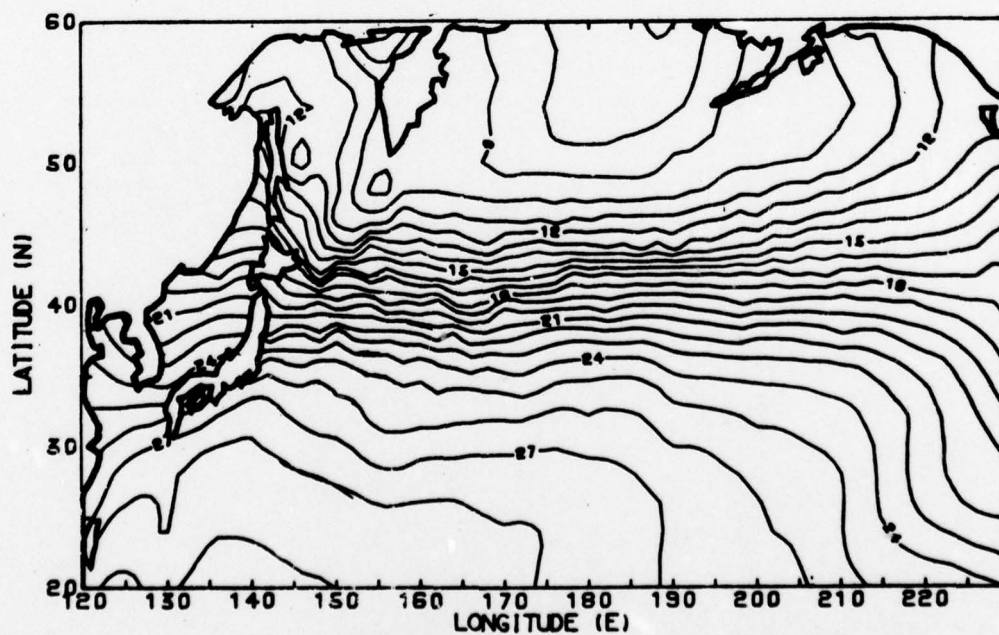


FIGURE 10.6 Monthly mean sea surface temperature is the mean of 12-hourly FNWC sea surface temperatures. Contour intervals are 1°C .

AIR TEMPERATURE (DEG. C) SEP 76

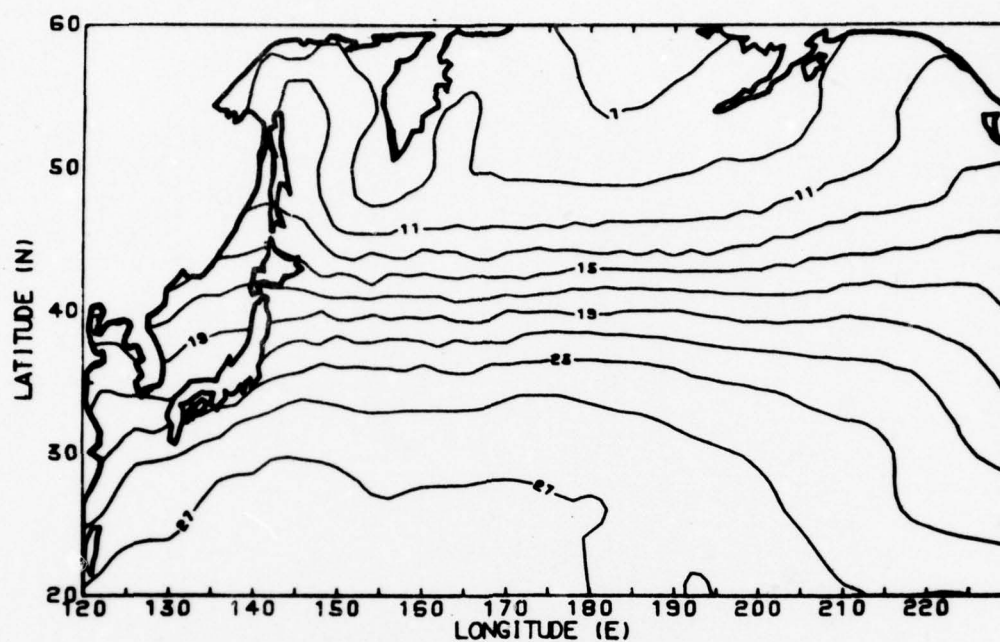


FIGURE 10.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) SEP 76

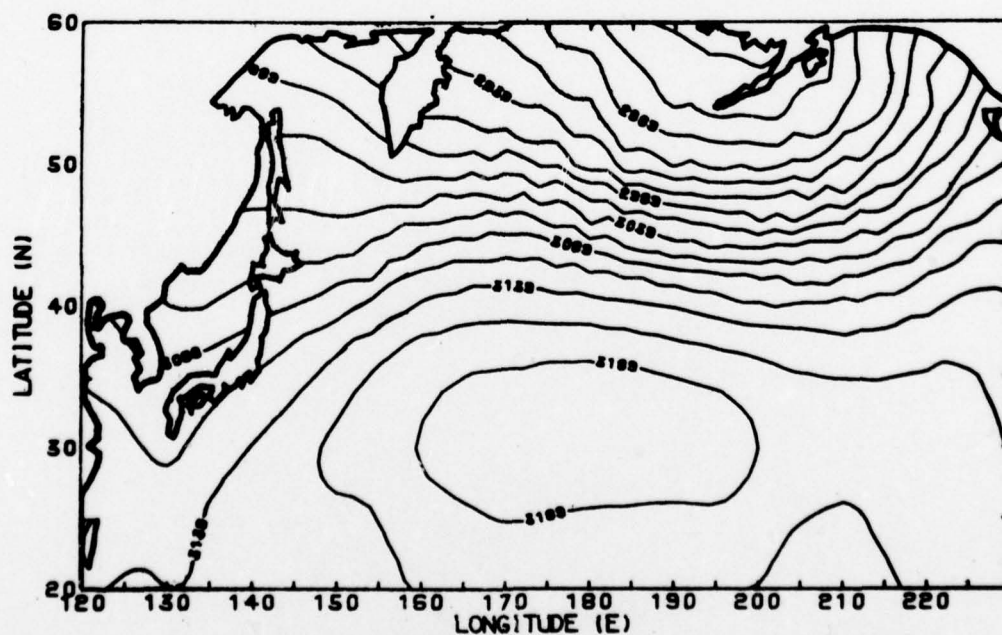


FIGURE 10.8 Monthly mean 700 mb height is the mean of 12-hourly FNWC 700 mb heights. Contour intervals are 25 meters.

VAPOR PRESSURE (MB) SEP 76

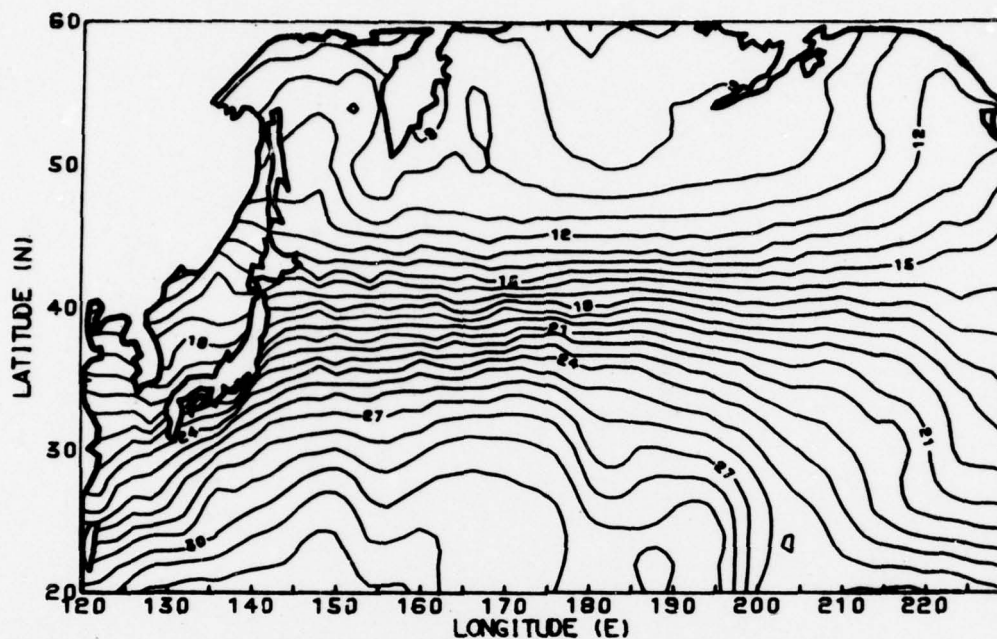


FIGURE 10.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10×10^{-4} CAL/CM \cdot 2 SEC)

SEP 76

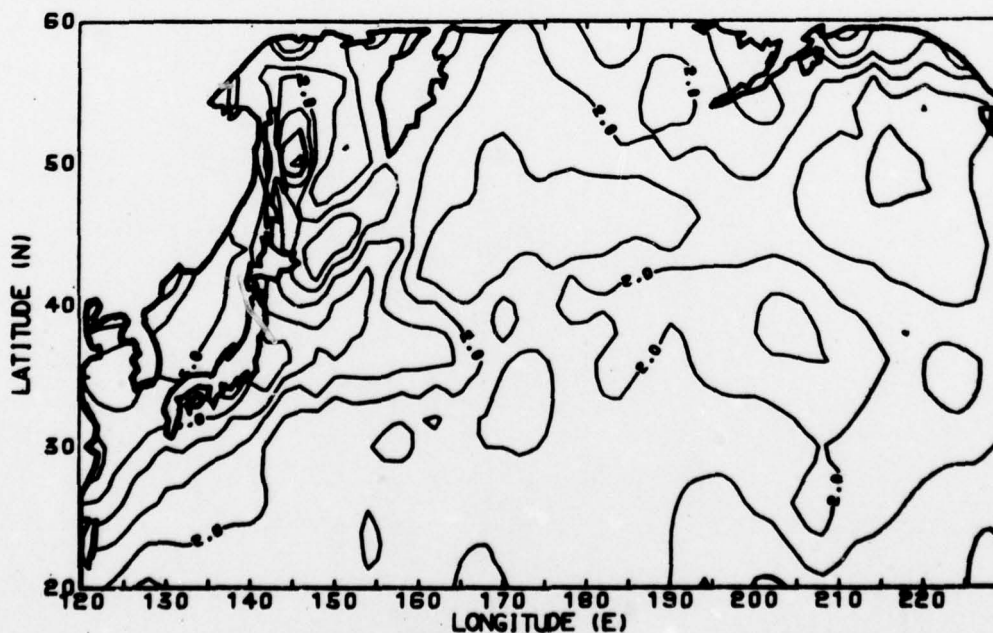


FIGURE 10.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm \cdot 2 sec.

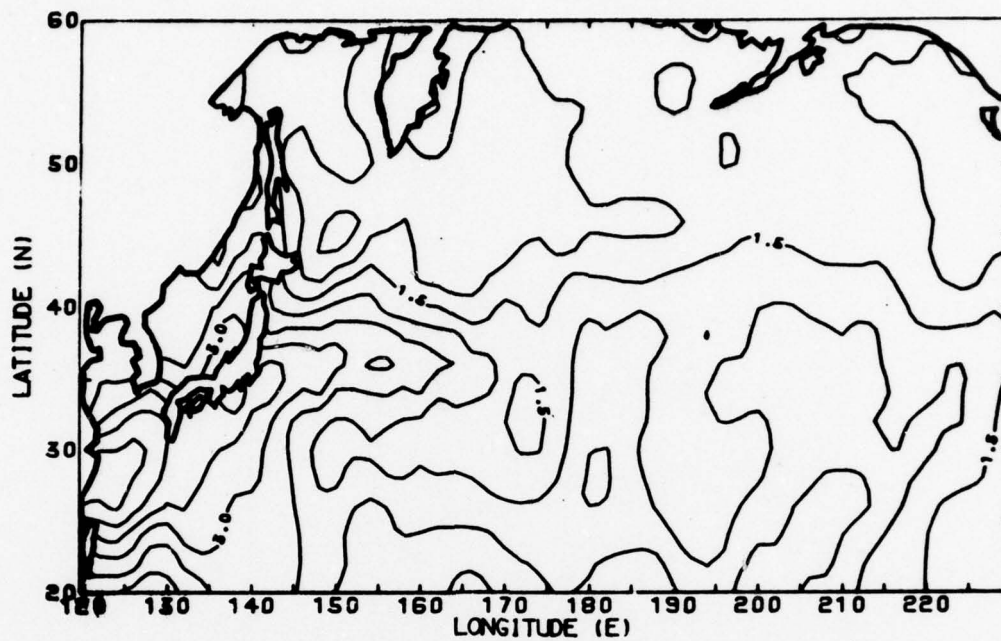


FIGURE 10.11 Monthly mean latent heat flux (ocean to atmosphere) is the mean of 12-hourly latent heat flux calculated from FNWC sea temperature, vapor pressure and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 0.5×10^{-3} cal/cm 2 sec.

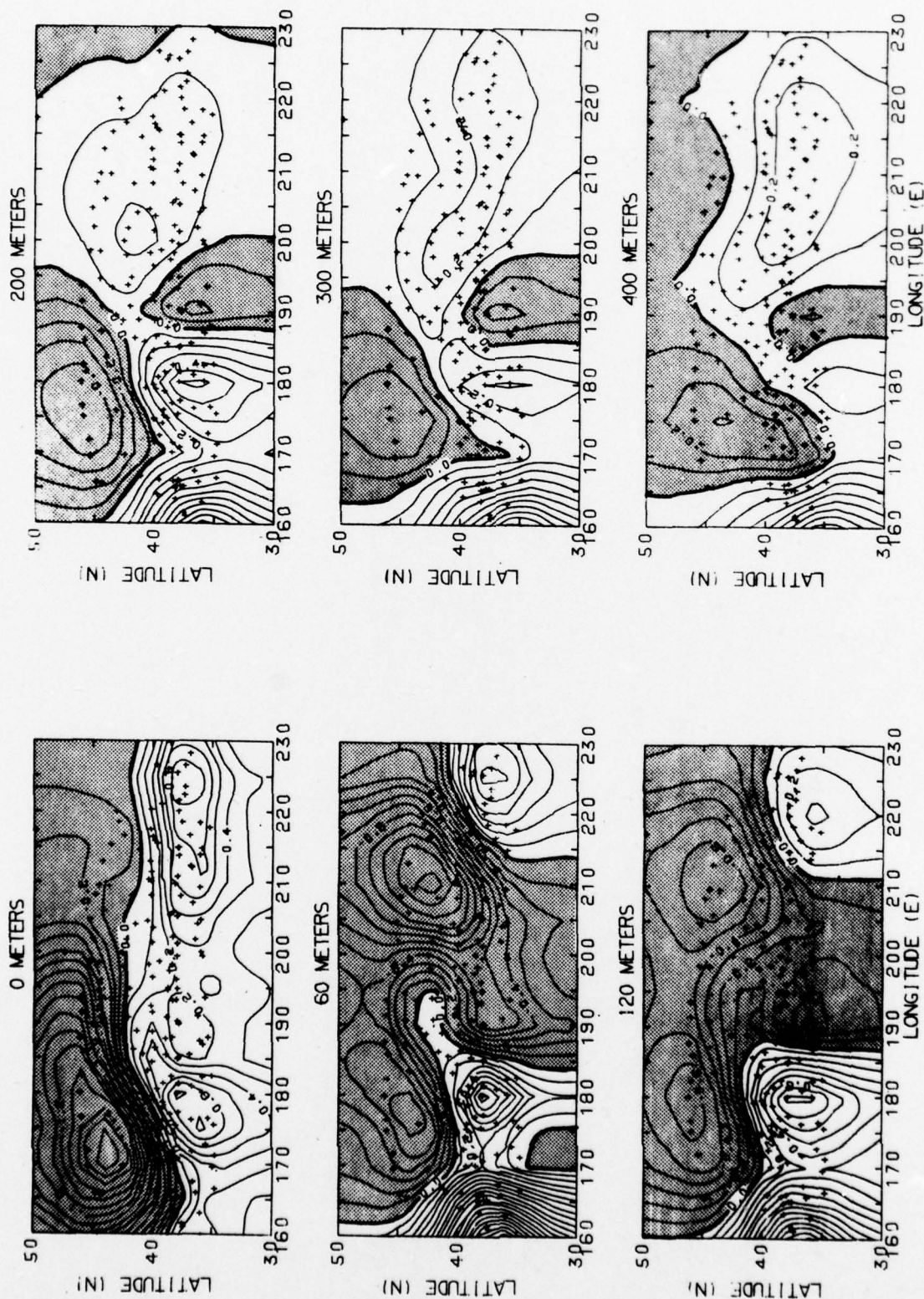


FIGURE 11. Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

BUOY PLOT FOR SEP. , 76

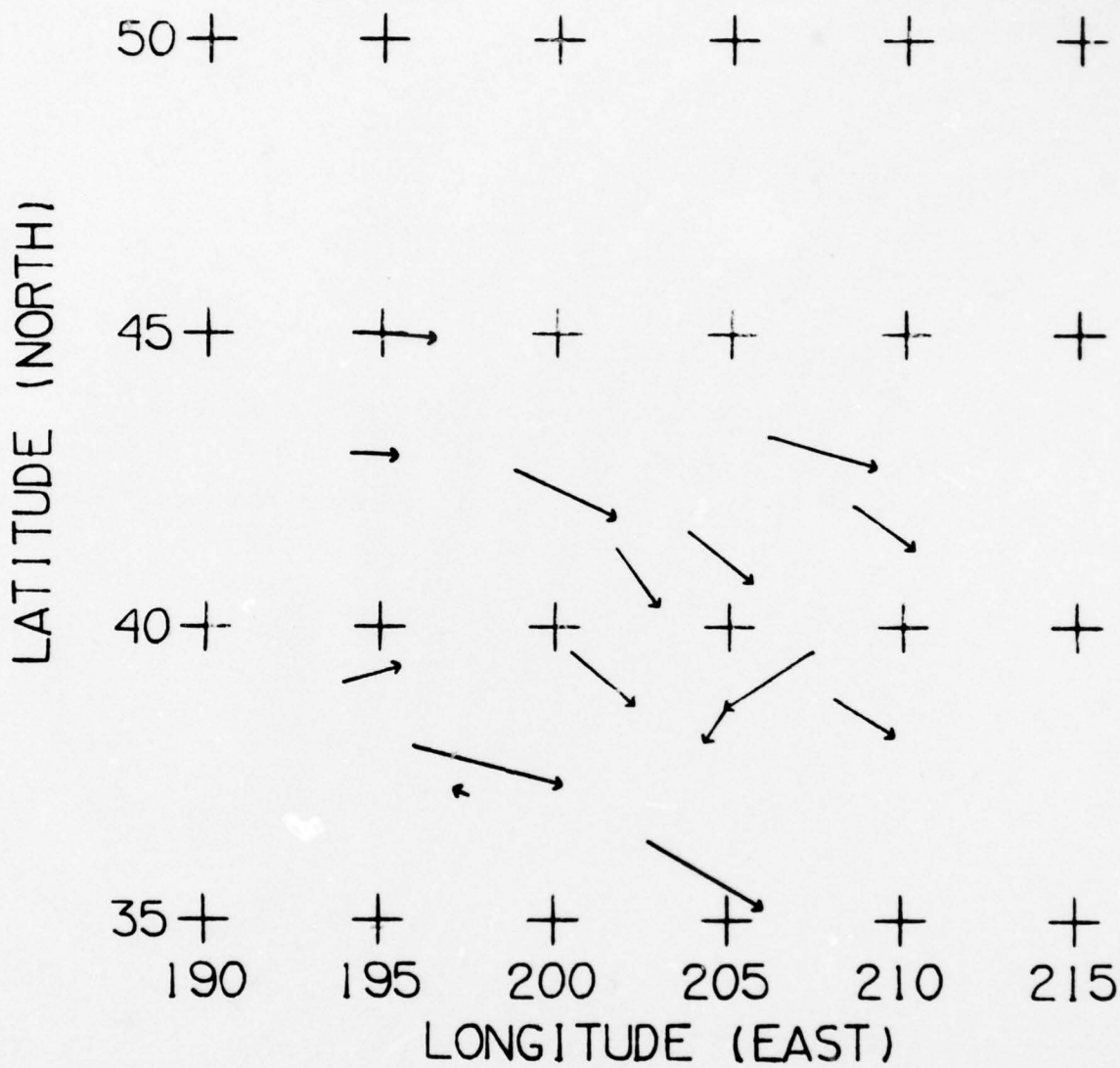


FIGURE 12.

Monthly buoy displacement vectors. Vectors are drawn from start point at beginning of month to terminal point at end of month.

WIND SPEED (M/SEC)

OCT 76

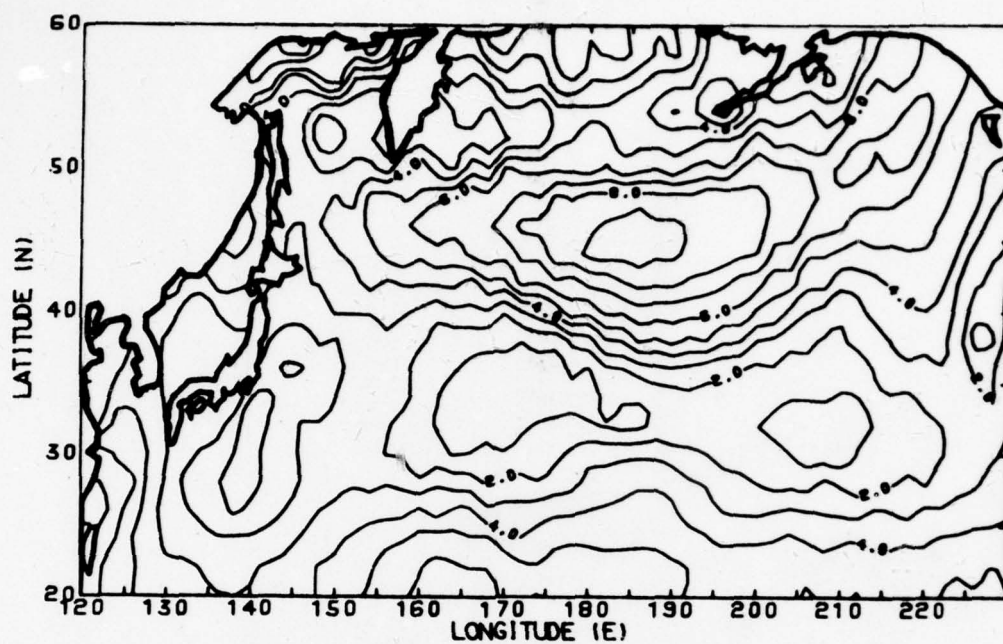


FIGURE 13.1 Absolute value of monthly mean vector wind velocities at 19.5 meters. Contour intervals are 1 m/sec.

WIND DIRECTION

OCT 76

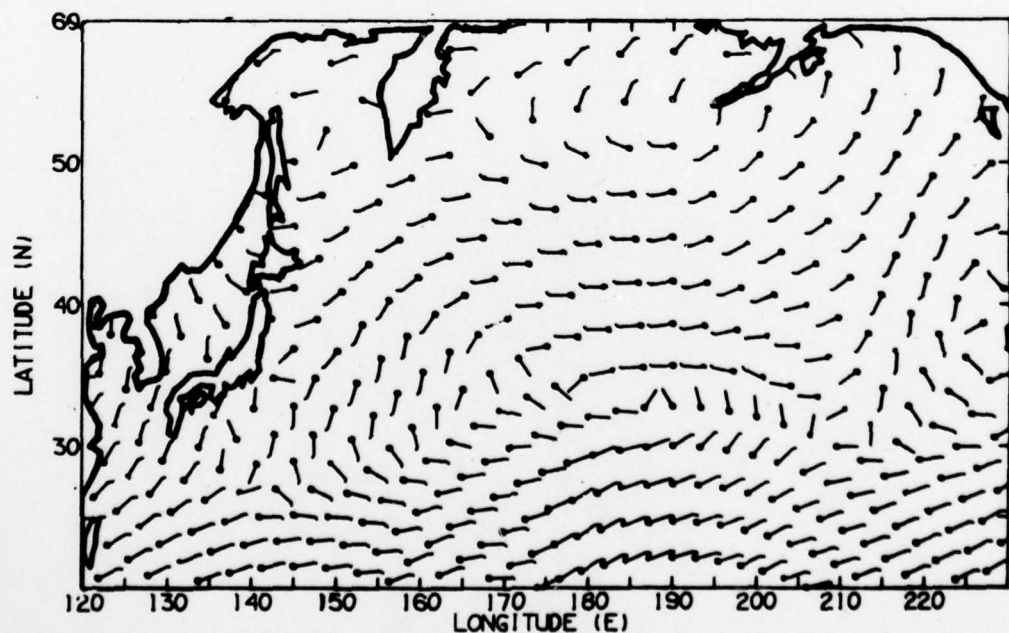


FIGURE 13.2 Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vanes on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

WIND STRESS (DYNES/CM²)

OCT 76

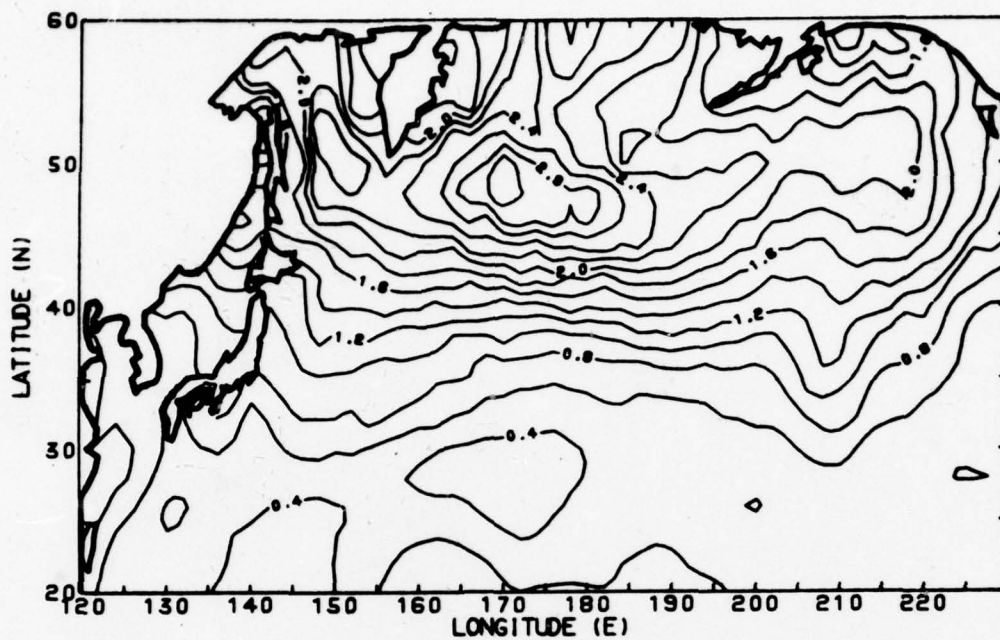


FIGURE 13.3 Monthly mean wind stress is the mean of 6-hourly wind stress at 10 meters calculated from FNWC wind data. Contour intervals are 0.2 dynes/cm².

CURL OF WIND STRESS (10^{-9} DYNES/CM³)

OCT 76

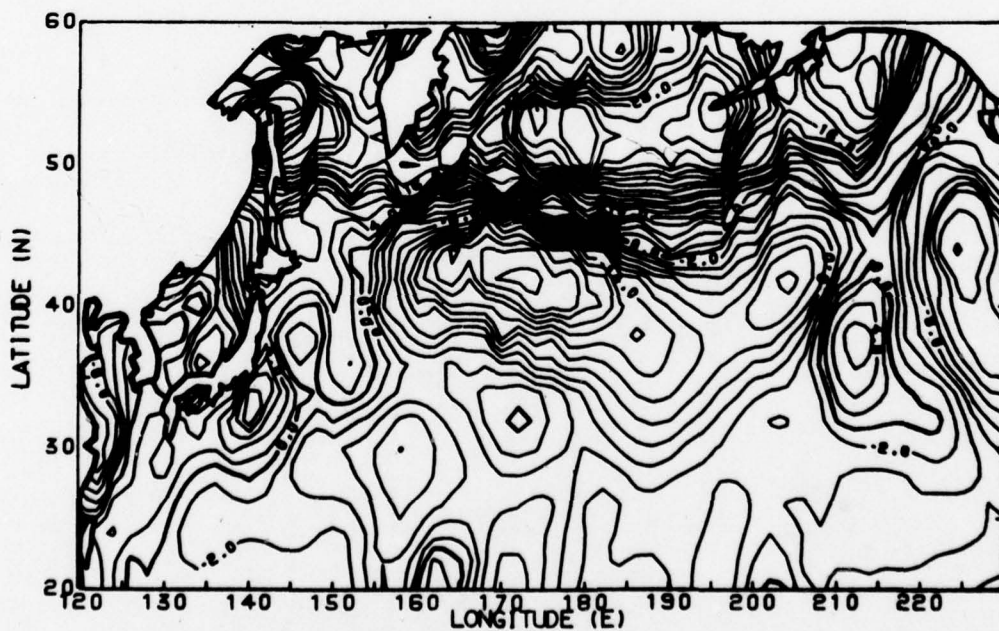


FIGURE 13.4 The vertical component of monthly mean wind stress curl is the mean of 6-hourly wind stress curl approximated by finite-differences from 6-hourly wind stresses at 10 meters. Isolines of zero curl are plotted heavily, and contour intervals are 4.0×10^{-9} dynes/cm³.

OCT 76

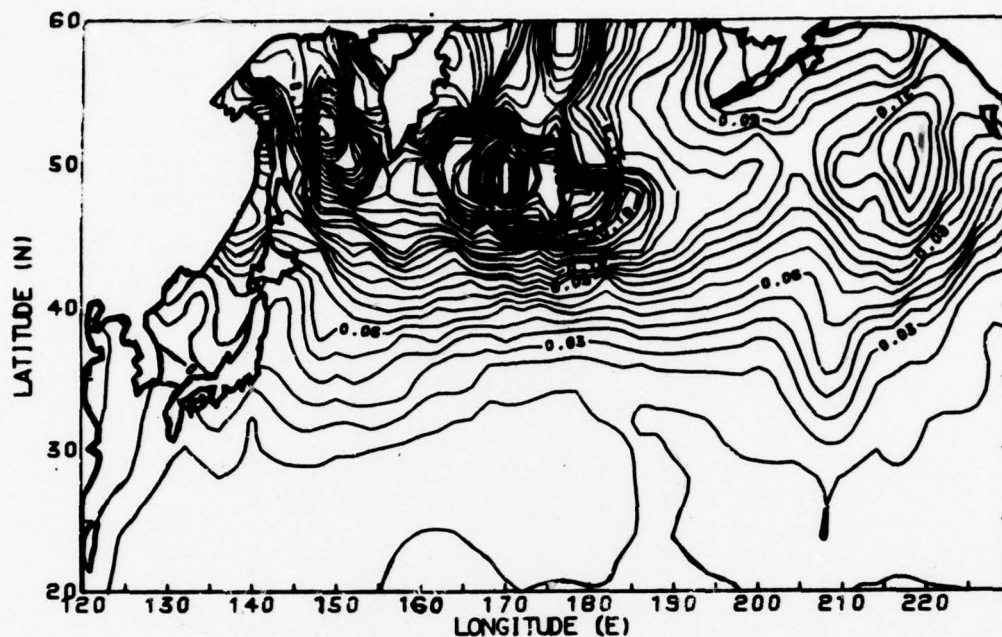


FIGURE 13.5 Monthly mean wind shear stress velocity cubed, U^3 is the mean of 6-hourly wind shear stress velocity cubed calculated from wind speed at 10 meters. Contour intervals are 0.0/ (m/sec)³.

OCT 76

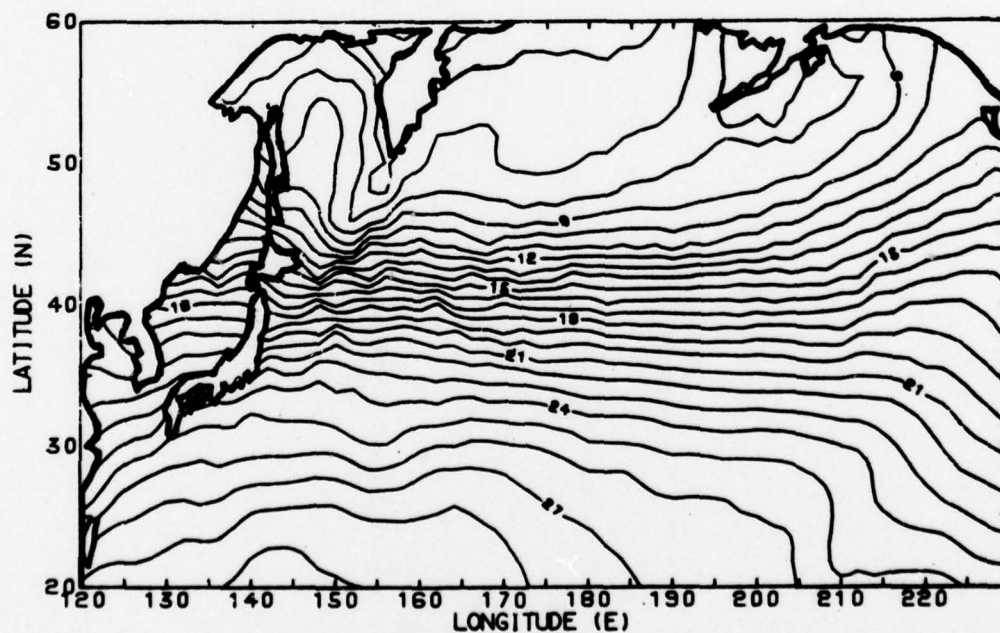


FIGURE 13.6 Monthly mean sea surface temperature is the mean of 12-hourly FNWC sea surface temperatures. Contour intervals are 1°C.

AIR TEMPERATURE (DEG. C) OCT 76

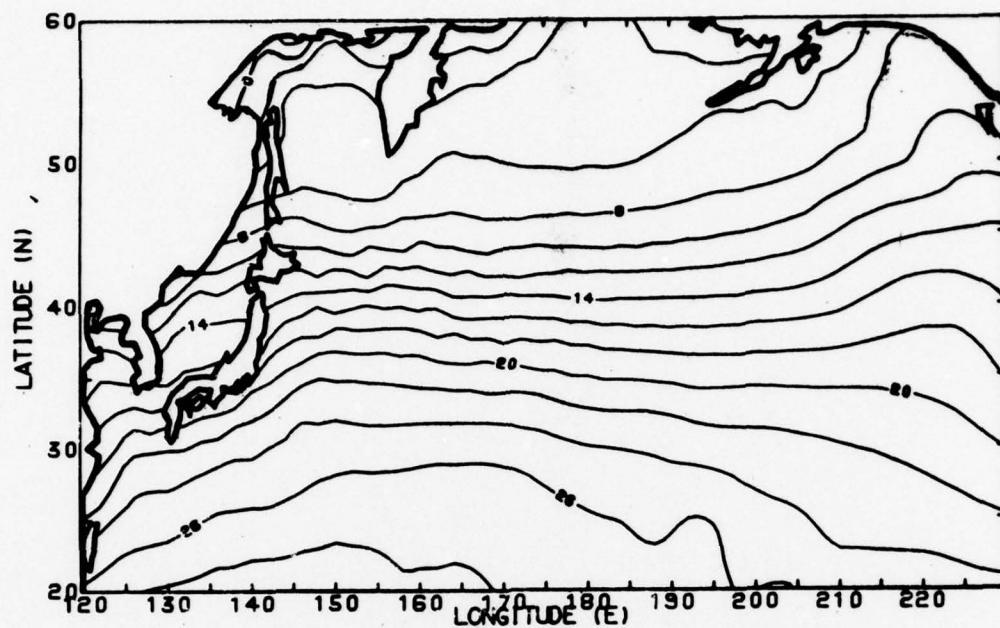


FIGURE 13.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) OCT 76

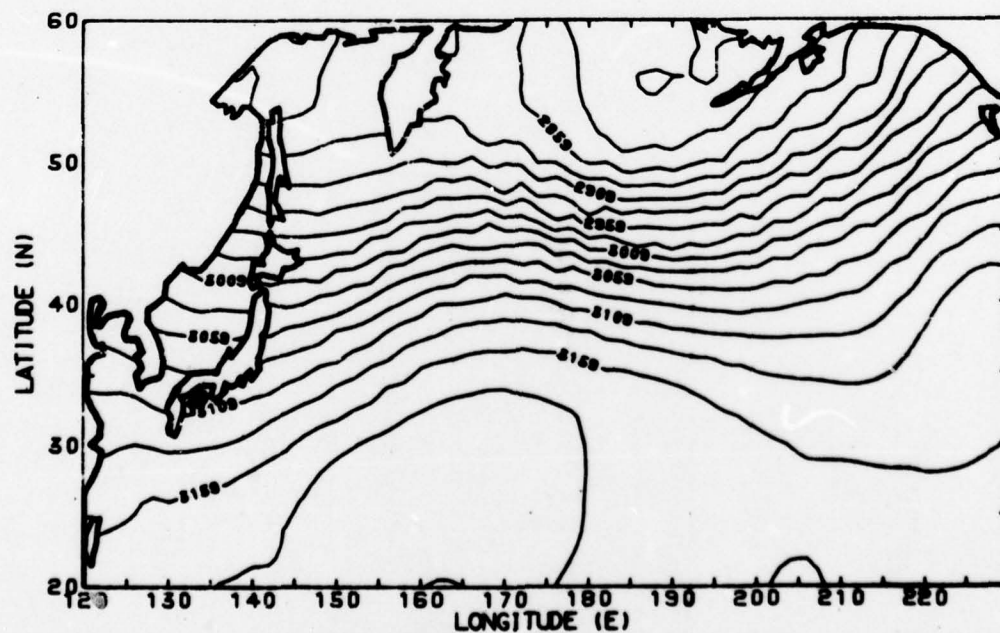


FIGURE 13.8 Monthly mean 700 mb height is the mean of 12-hourly FNWC 700 mb heights. Contour intervals are 25 meters.

VAPOR PRESSURE (MB) OCT 76

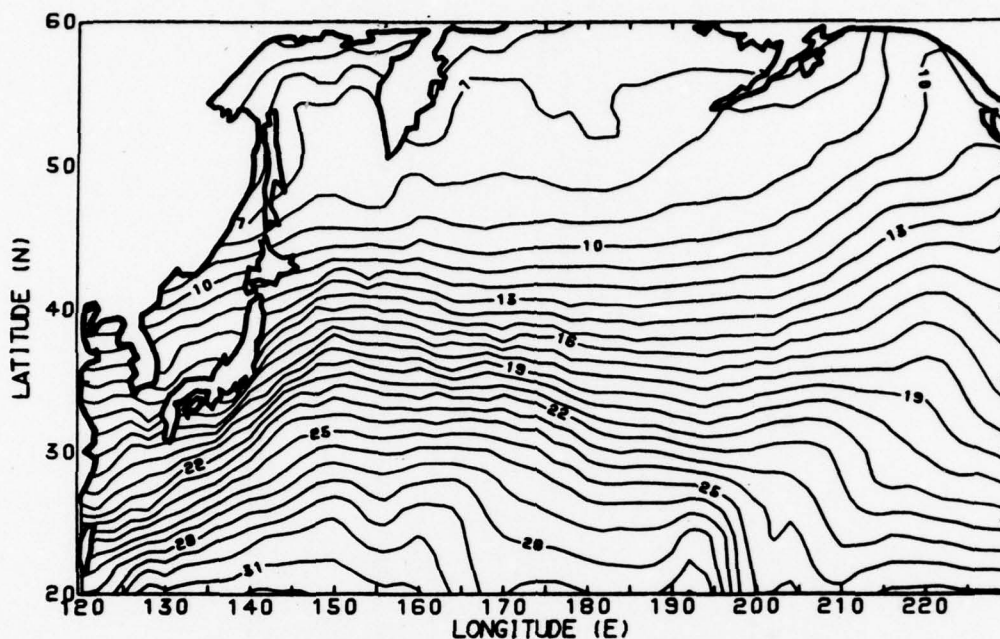


FIGURE 13.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM² SEC)

OCT 76

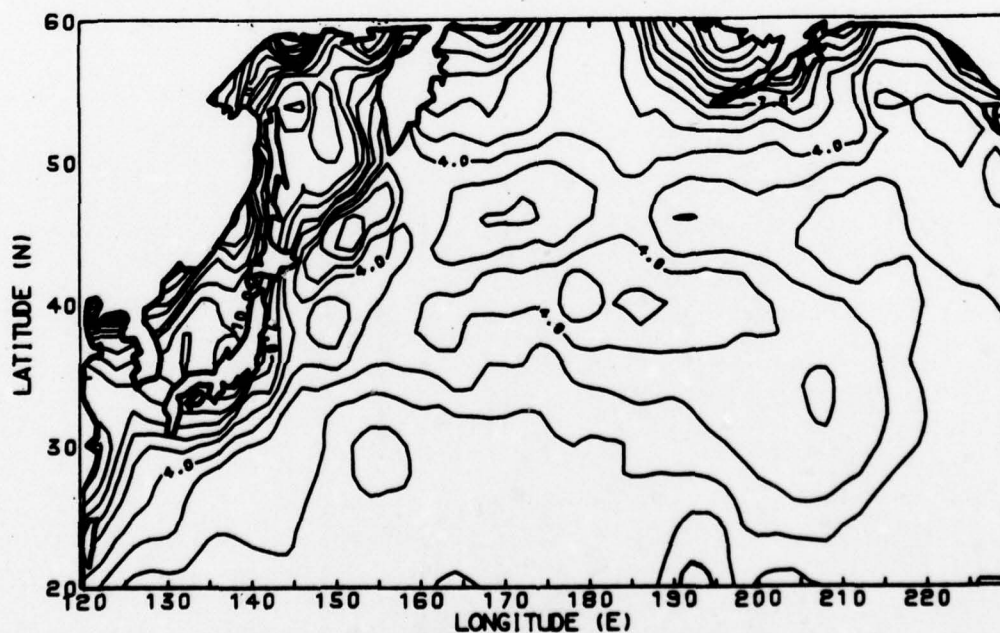


FIGURE 13.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm² sec.

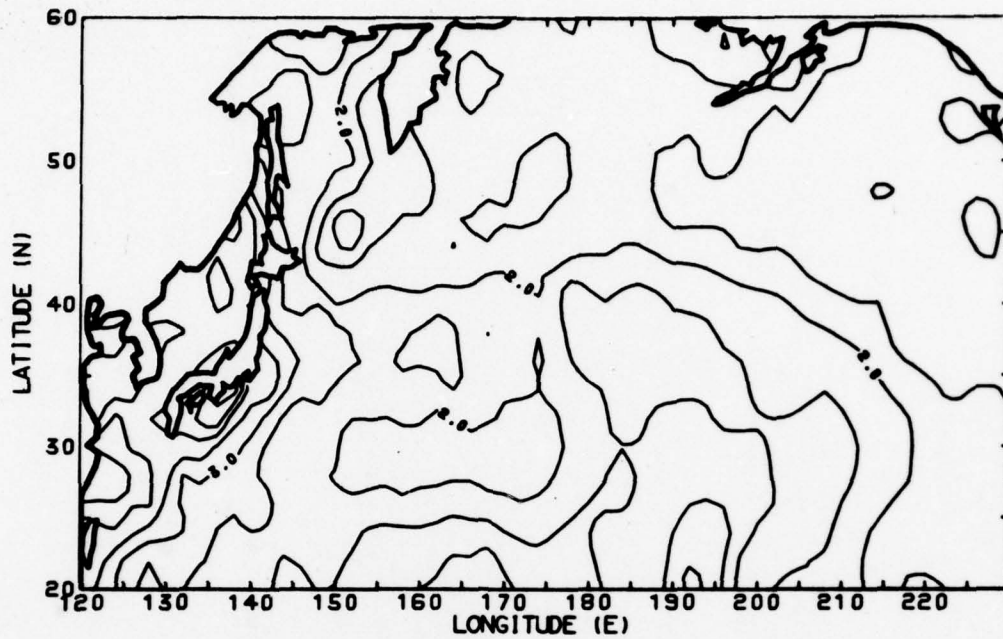


FIGURE 13.11 Monthly mean latent heat flux (ocean to atmosphere) is the mean of 12-hourly latent heat flux calculated from FNWC sea temperature, vapor pressure and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 0.5×10^{-3} cal/cm² sec.

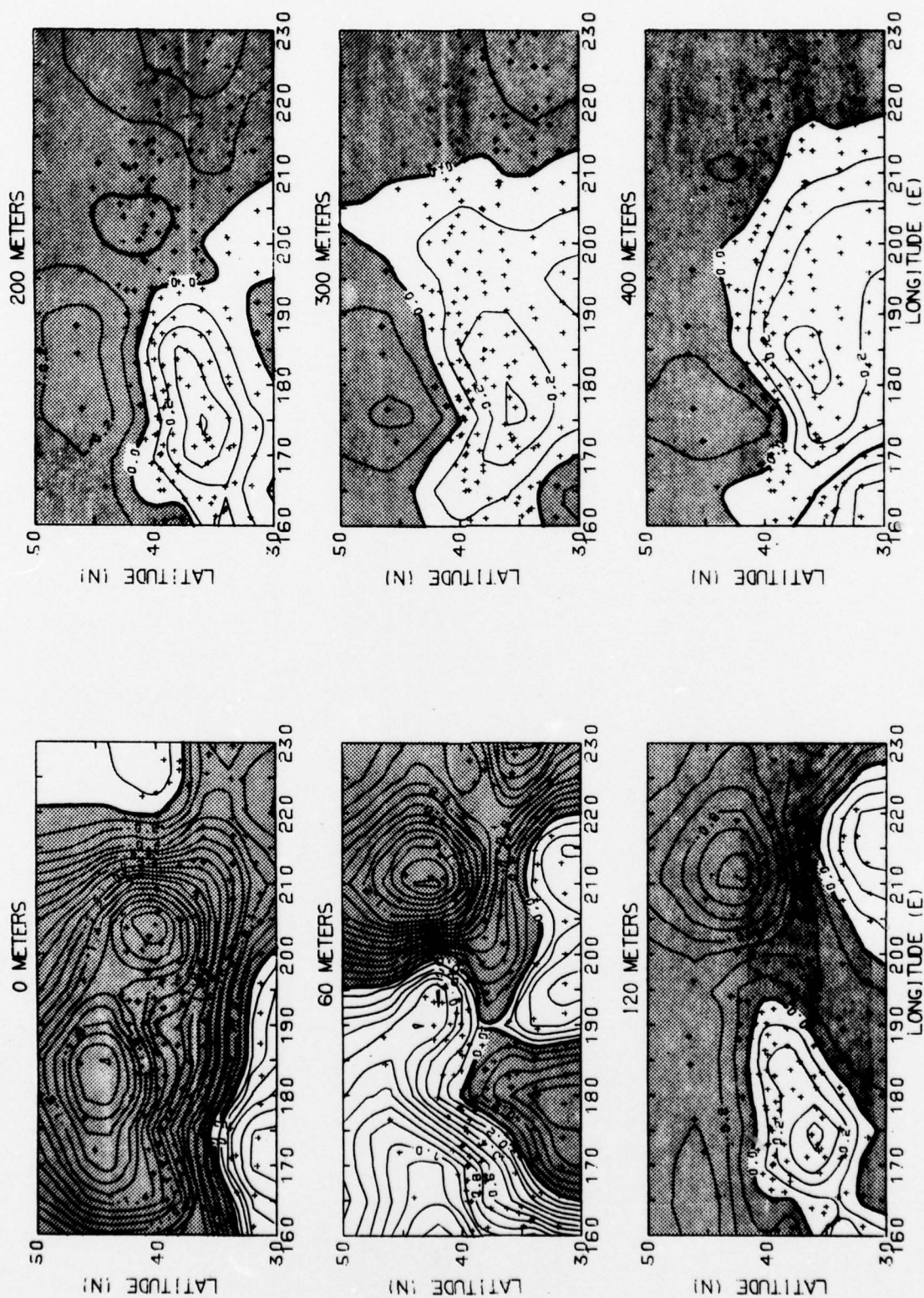


FIGURE 14. Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

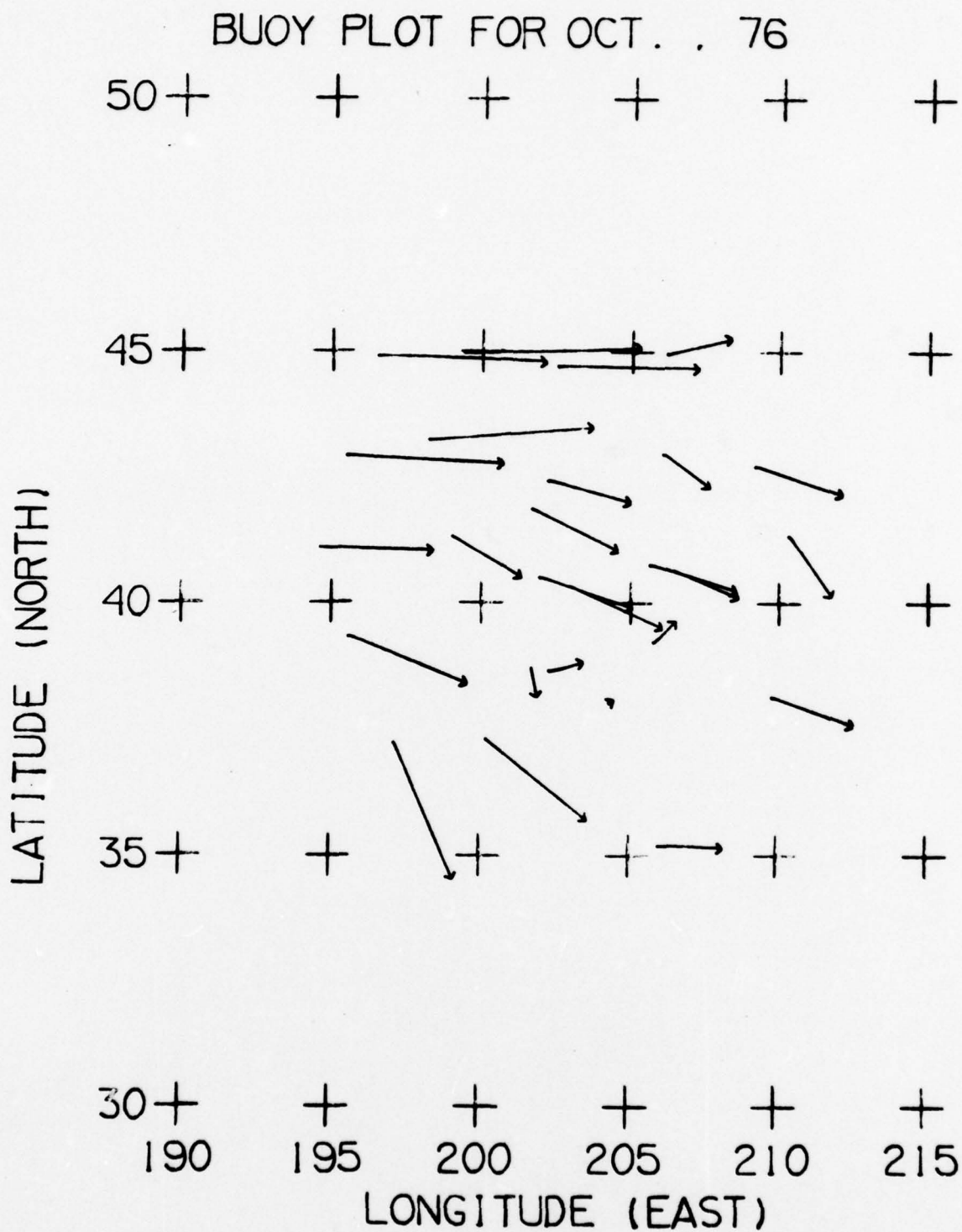


FIGURE 15.

Monthly buoy displacement vectors. Vectors are drawn from start point at beginning of month to terminal point at end of month.

WIND SPEED (M/SEC)

NOV 76

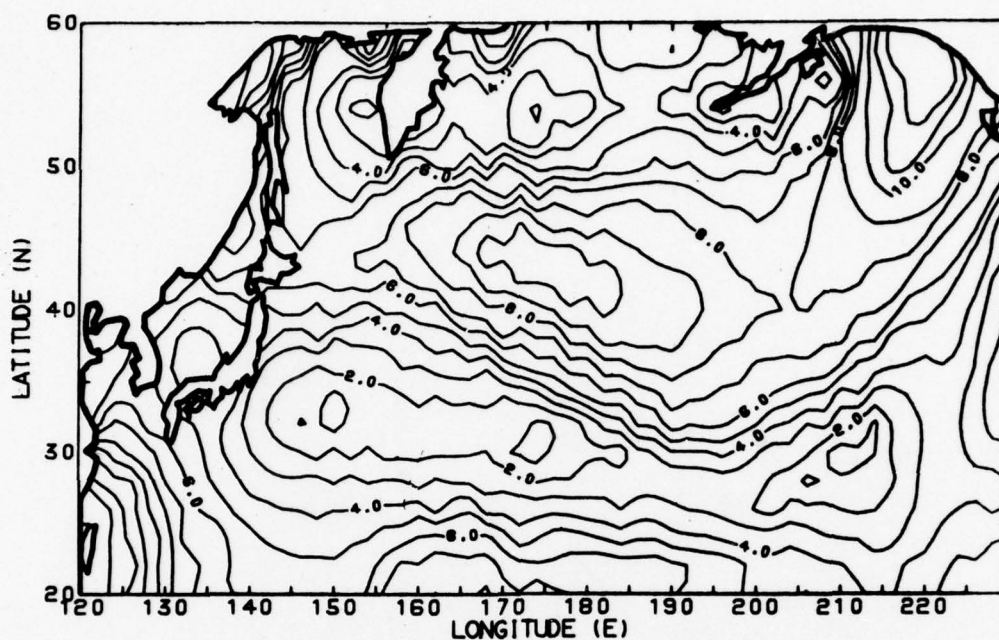


FIGURE 16.1 Absolute value of monthly mean vector wind velocities at 19.5 meters. Contour intervals are 1 m/sec.

WIND DIRECTION

NOV 76

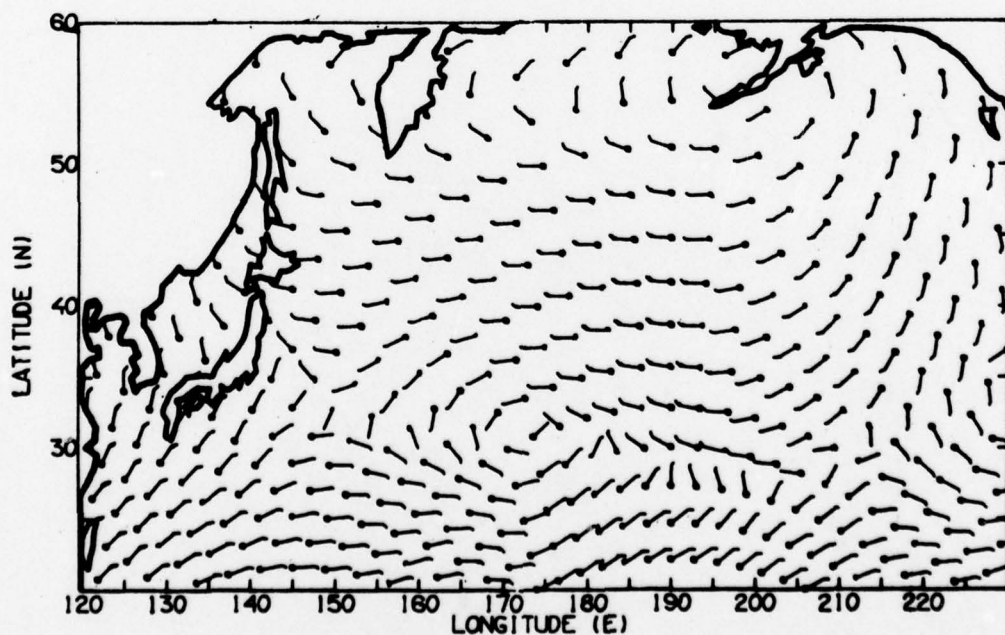


FIGURE 16.2 Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vanes on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

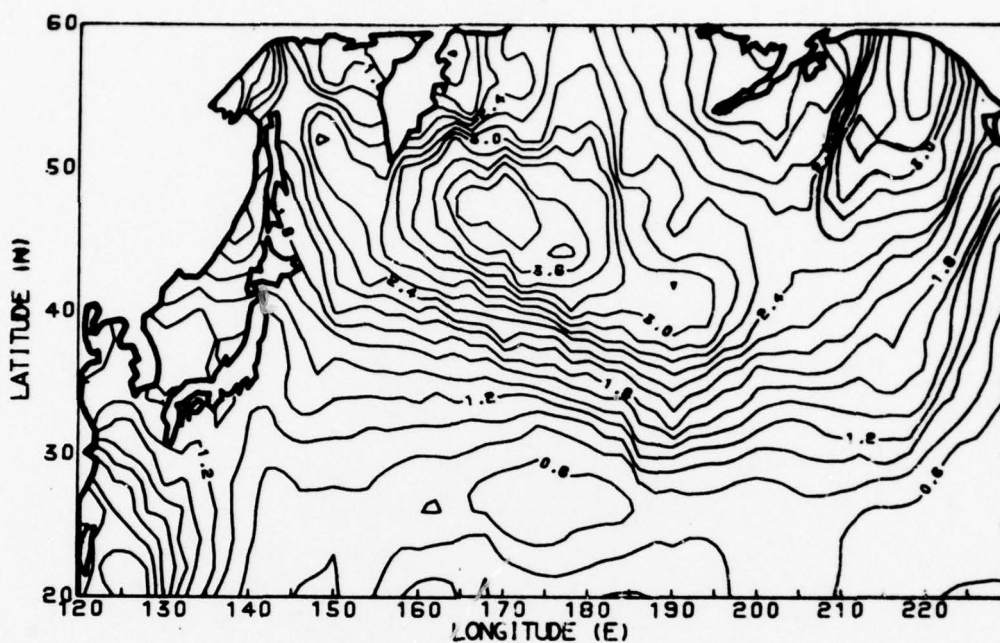


FIGURE 16.3 Monthly mean wind stress is the mean of 6-hourly wind stress at 10 meters calculated from FNWC wind data. Contour intervals are 0.2 dynes/cm².

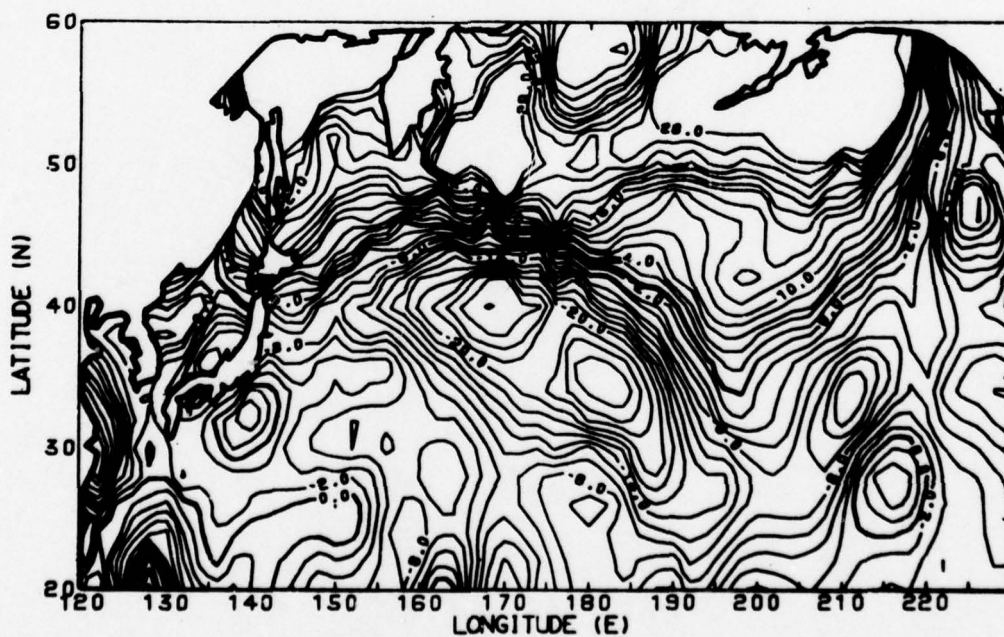


FIGURE 16.4 The vertical component of monthly mean wind stress curl is the mean of 6-hourly wind stress curl approximated by finite-differences from 6-hourly wind stresses at 10 meters. Isolines of zero curl are plotted heavily, and contour intervals are 4.0×10^{-9} dynes/cm³.

U STAR CUBED ((M/SEC)**3)

NOV 76

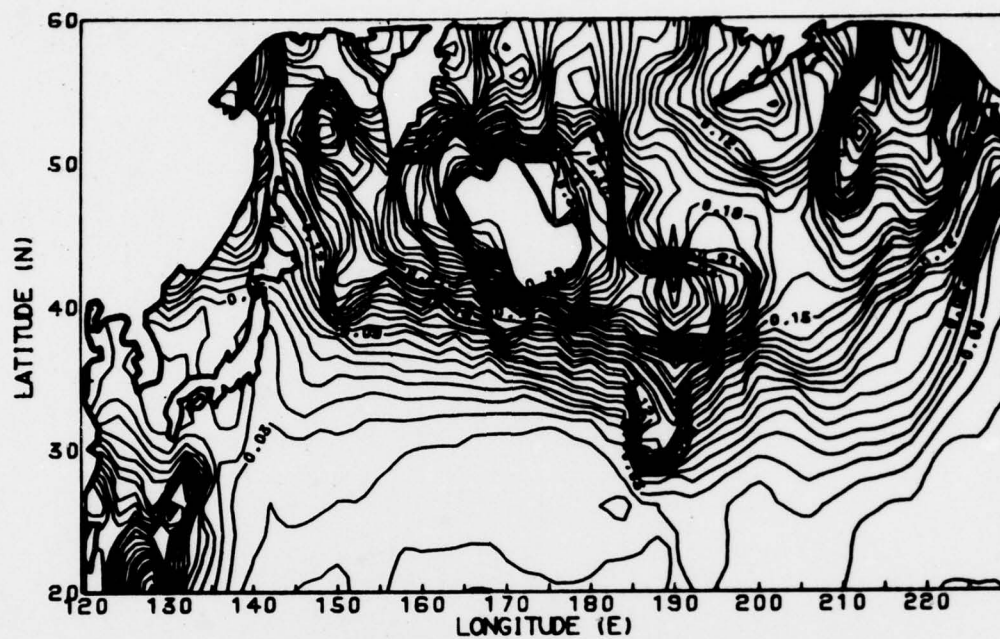


FIGURE 16.5 Monthly mean wind shear stress velocity cubed, U_*^3 is the mean of 6-hourly wind shear stress velocity cubed calculated from wind speed at 10 meters. Contour intervals are $0.01 (\text{m/sec})^3$.

SEA SURFACE TEMPERATURE (DEG.C)

NOV 76

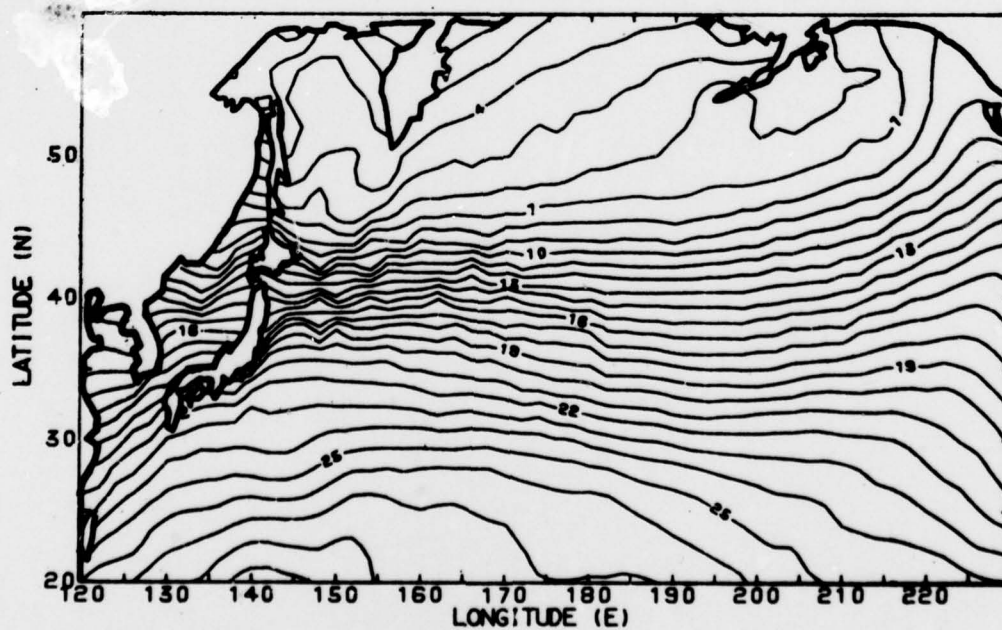


FIGURE 16.6 Monthly mean sea surface temperature is the mean of 12-hourly FNWC sea surface temperatures. Contour intervals are 1°C .

AIR TEMPERATURE (DEG. C) NOV 76

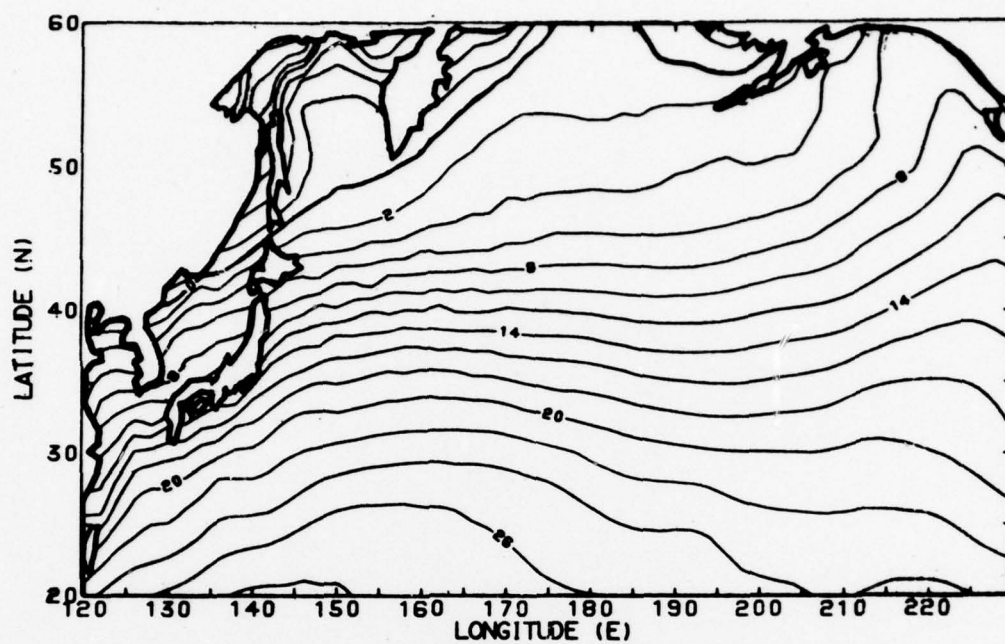


FIGURE 16.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) NOV 76

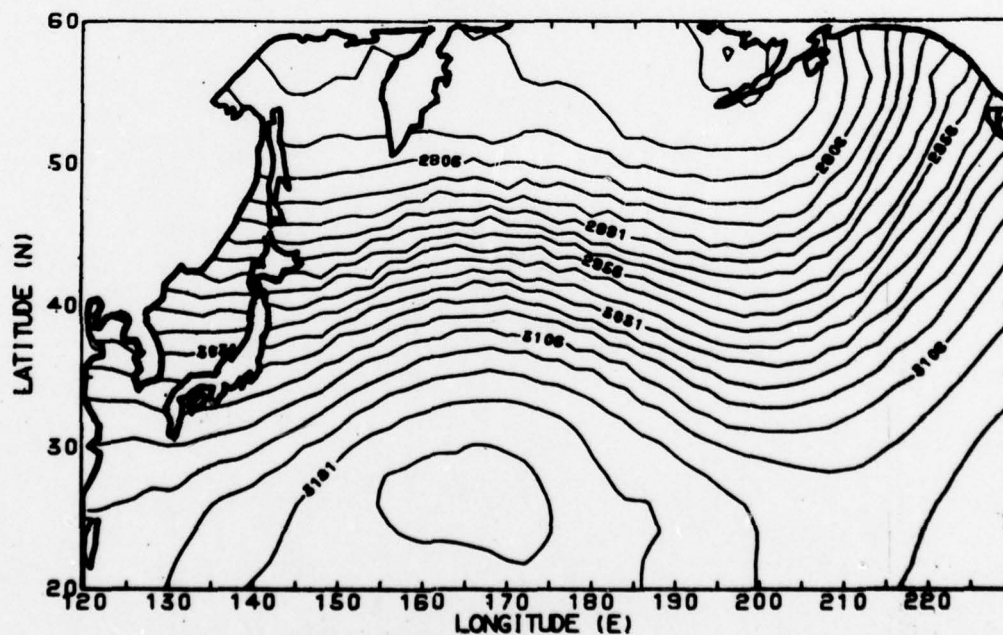


FIGURE 16.8 Monthly mean 700 mb height is the mean of 12-hourly FNWC 700 mb heights. Contour intervals are 25 meters.

VAPOR PRESSURE (MB) NOV 76

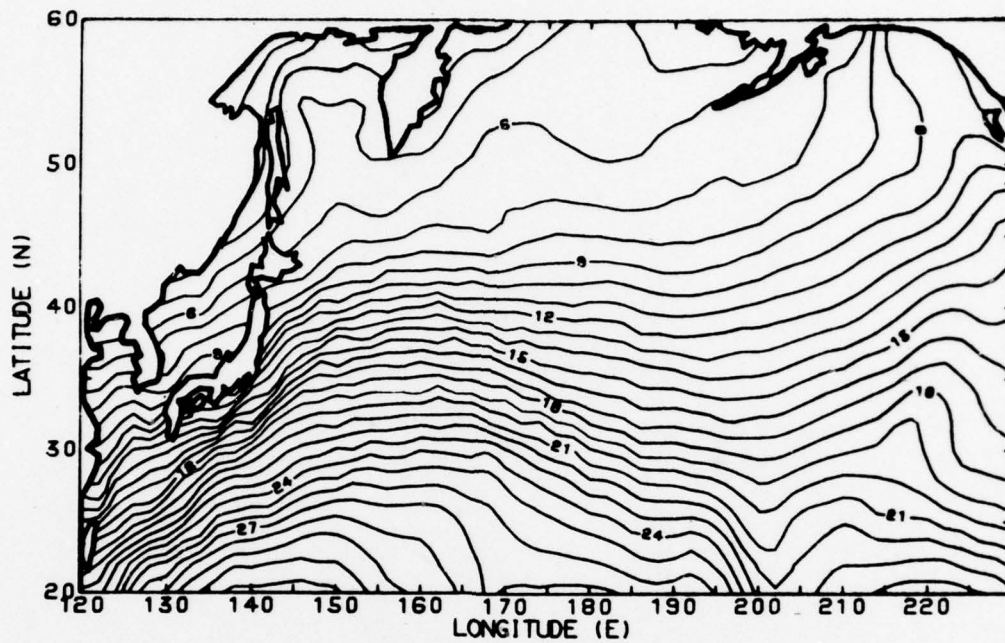


FIGURE 16.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM² SEC) NOV 76

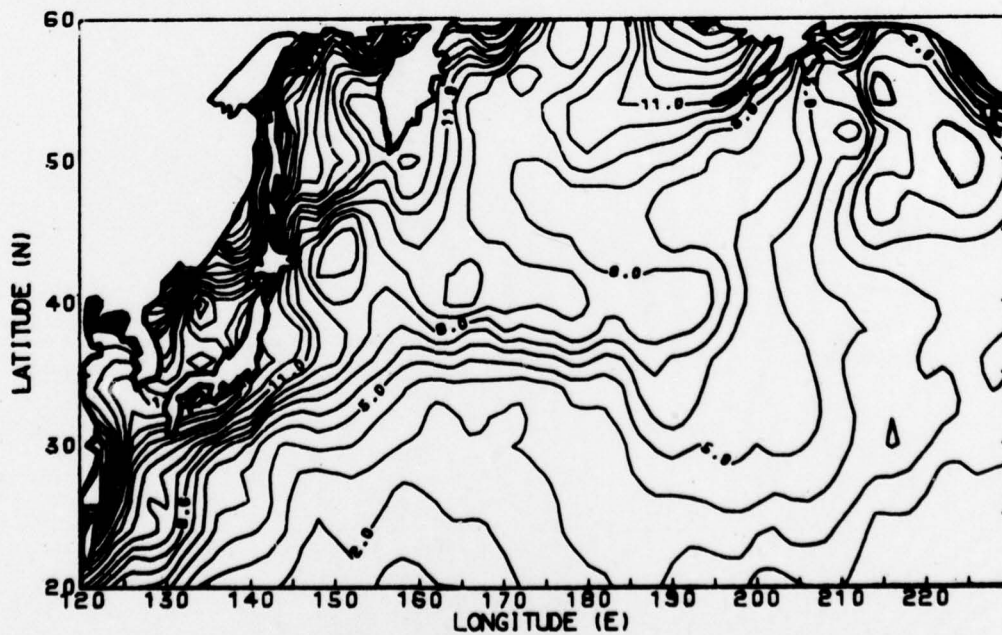


FIGURE 16.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm² sec.

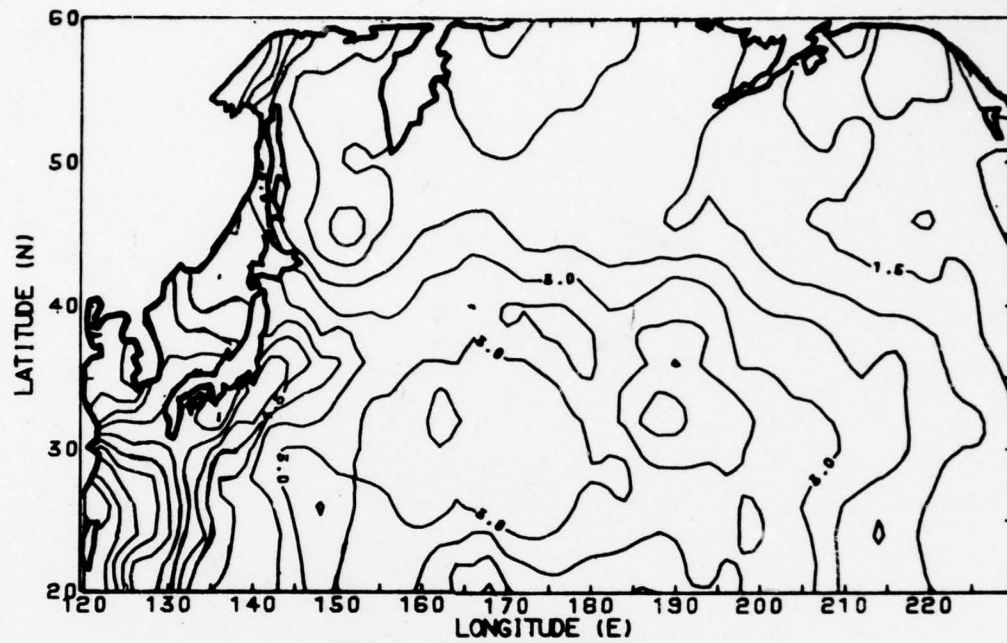


FIGURE 16.11 Monthly mean latent heat flux (ocean to atmosphere) is the mean of 12-hourly latent heat flux calculated from FNCW sea temperature, vapor pressure and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 0.5×10^{-3} cal/cm 2 sec.

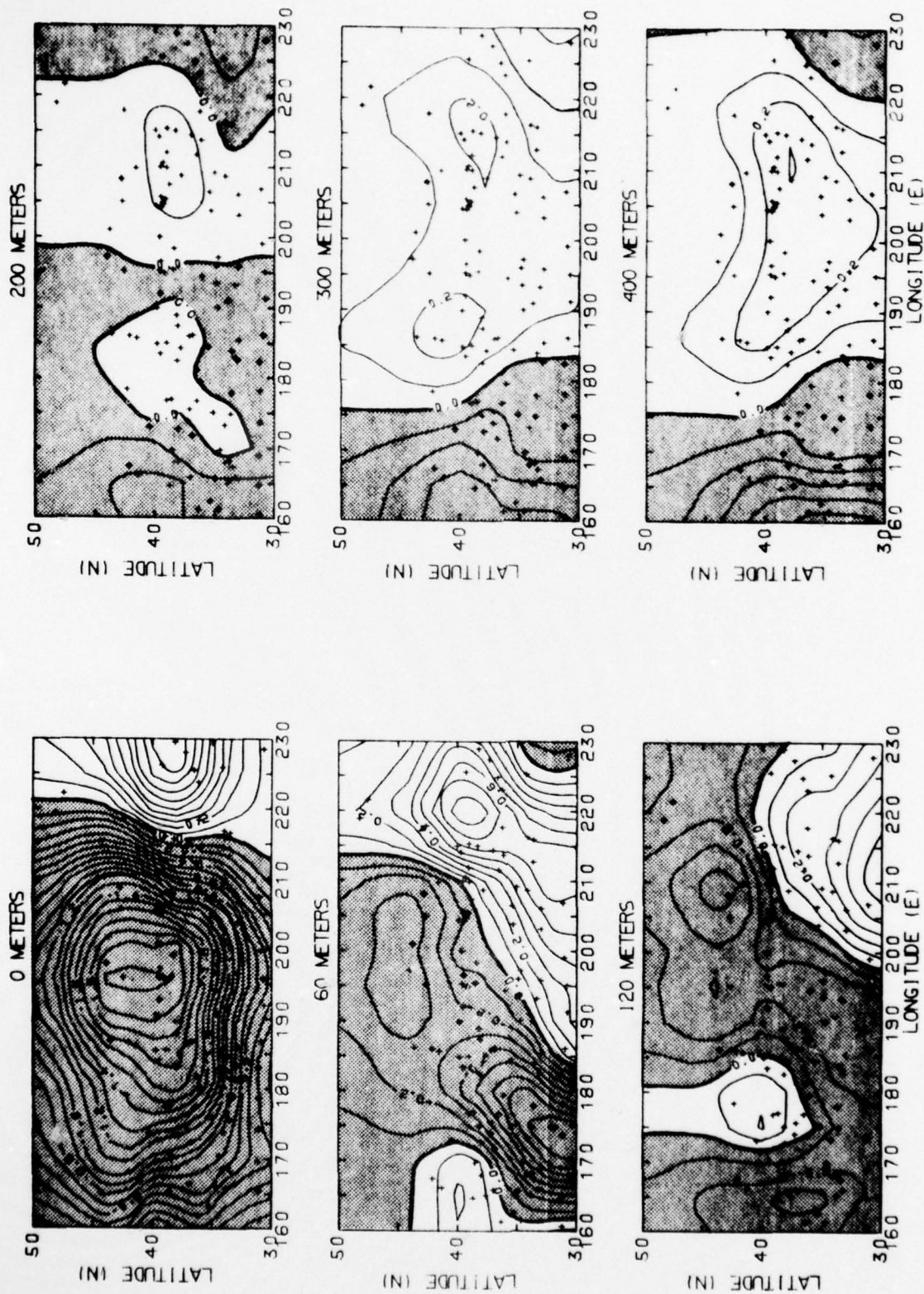


FIGURE 17. Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

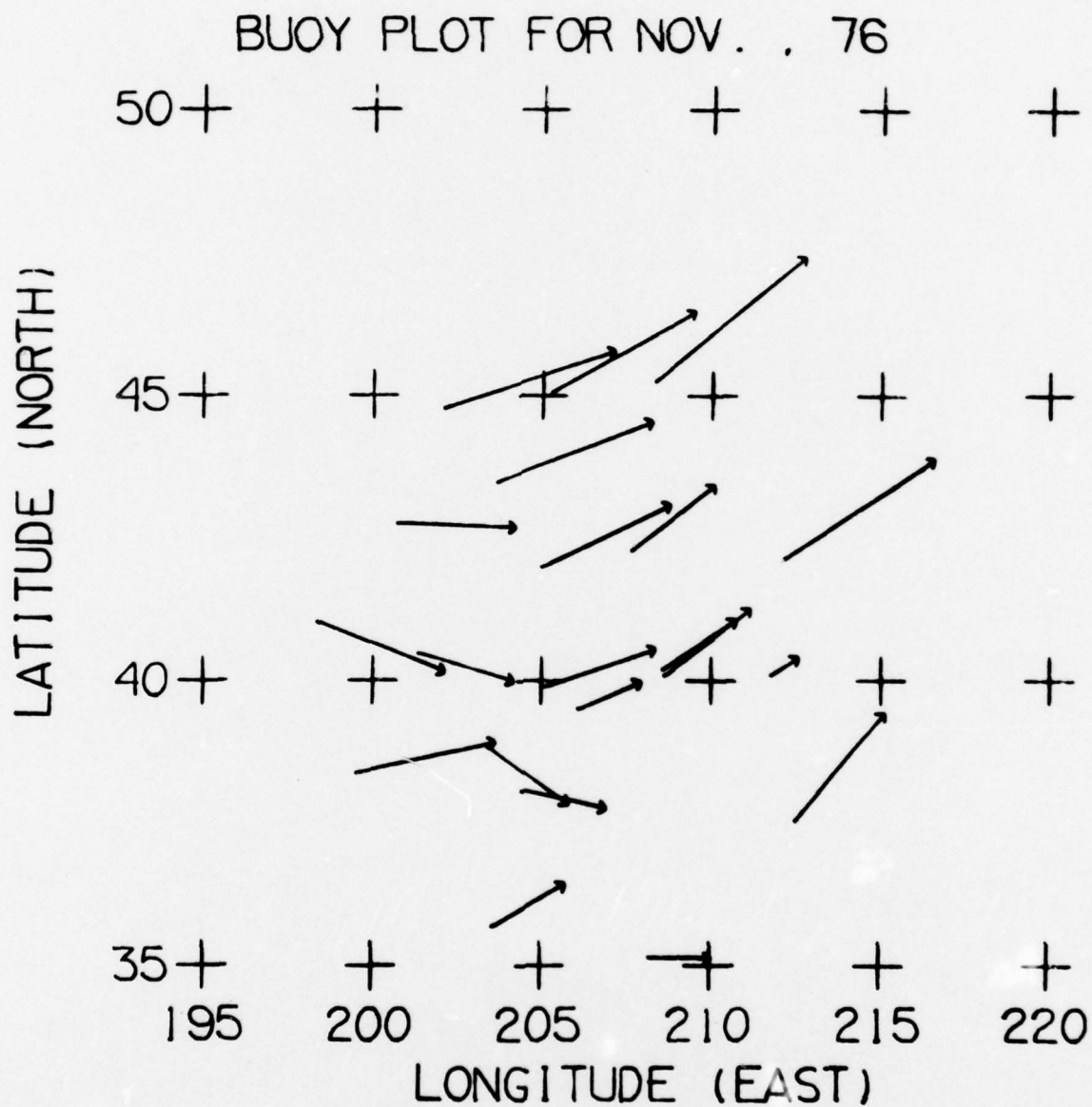


FIGURE 18.

Monthly buoy displacement vectors. Vectors are drawn from start point at beginning of month to terminal point at end of month.

WIND SPEED (M/SEC)

DEC 76

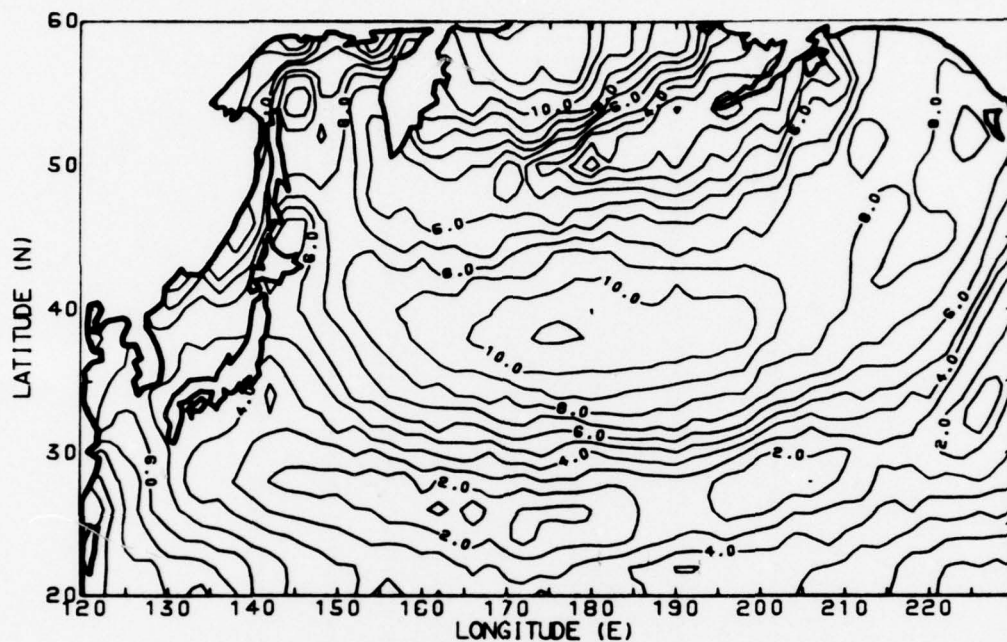


FIGURE 19.1 Absolute value of monthly mean vector wind velocities at 19.5 meters. Contour intervals are 1 m/sec.

WIND DIRECTION

DEC 76

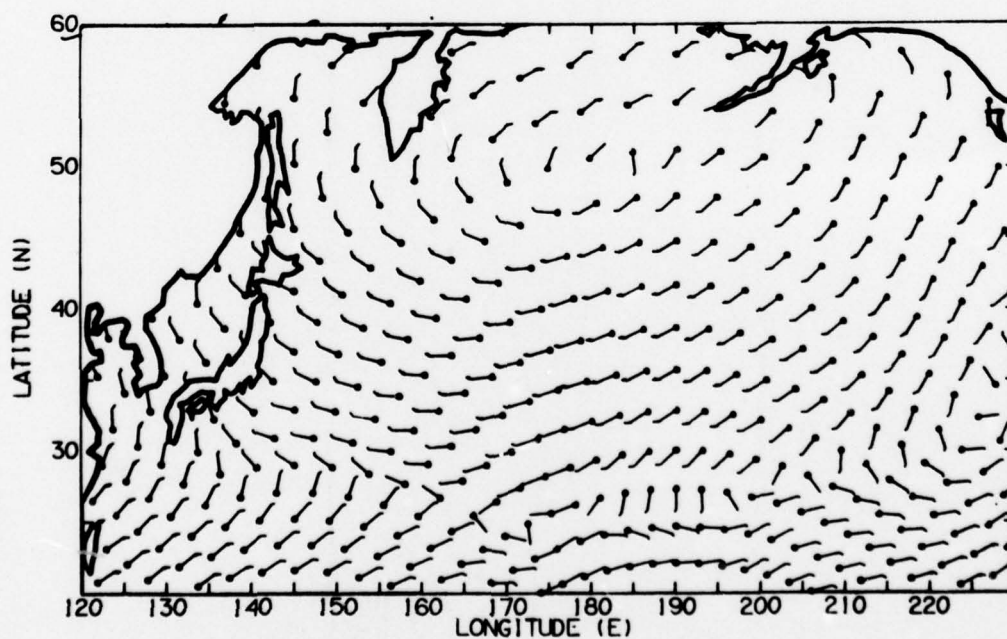


FIGURE 19.2 Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vanes on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

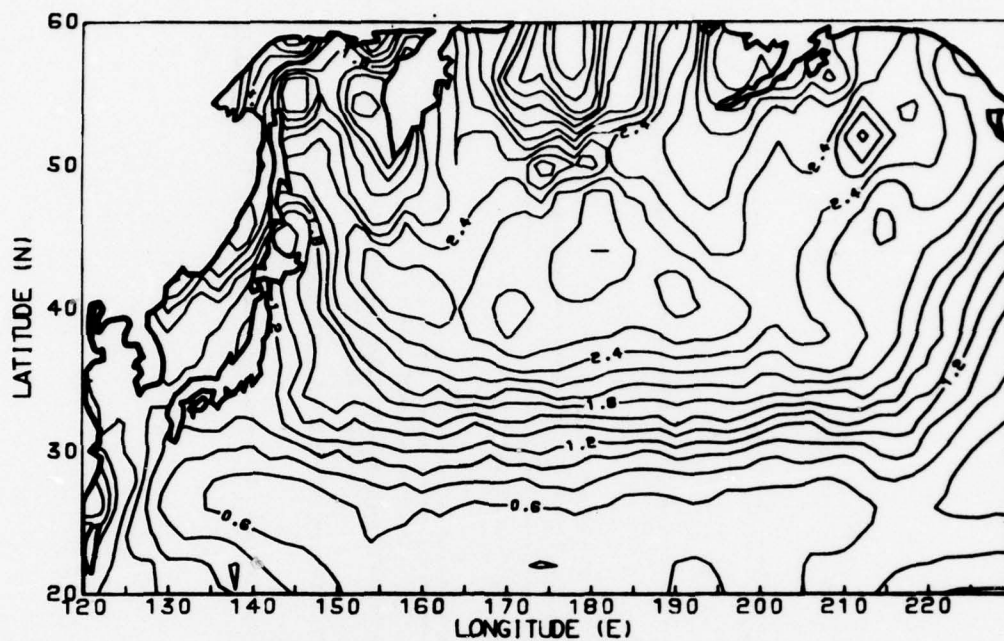


FIGURE 19.3 Monthly mean wind stress is the mean of 6-hourly wind stress at 10 meters calculated from FNWC wind data. Contour intervals are 0.2 dynes/cm².

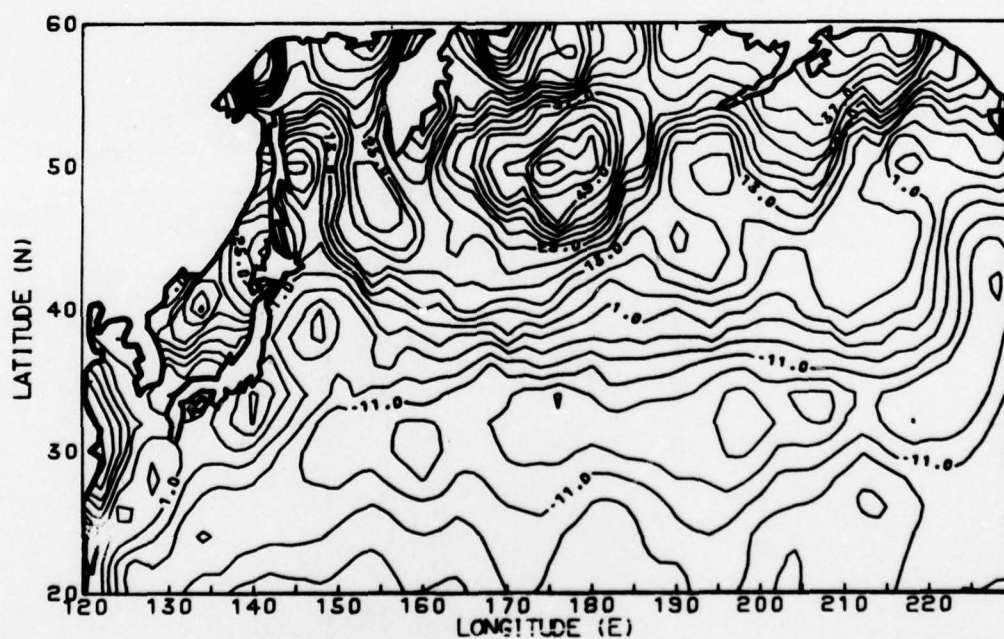
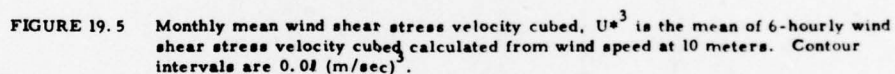
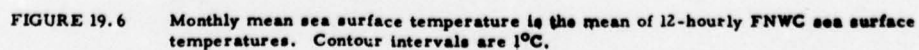


FIGURE 19.4 The vertical component of monthly mean wind stress curl is the mean of 6-hourly wind stress curl approximated by finite-differences from 6-hourly wind stresses at 10 meters. Isolines of zero curl are plotted heavily, and contour intervals are $4.0 \times 10^{•••9}$ dynes/cm³.

DEC 76



DEC 76



AIR TEMPERATURE (DEG. C) DEC 76

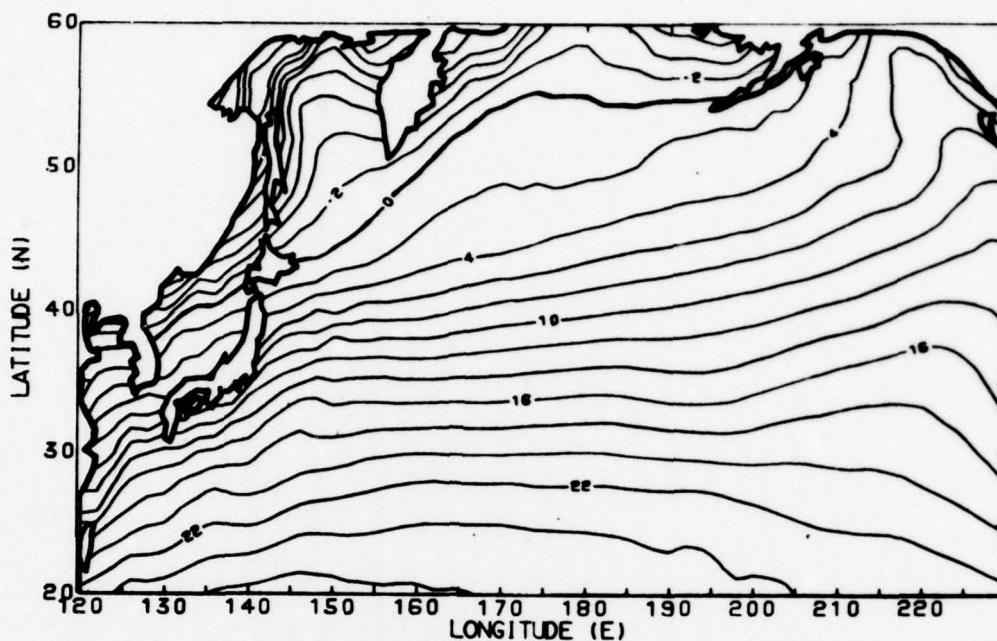


FIGURE 19.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) DEC 76

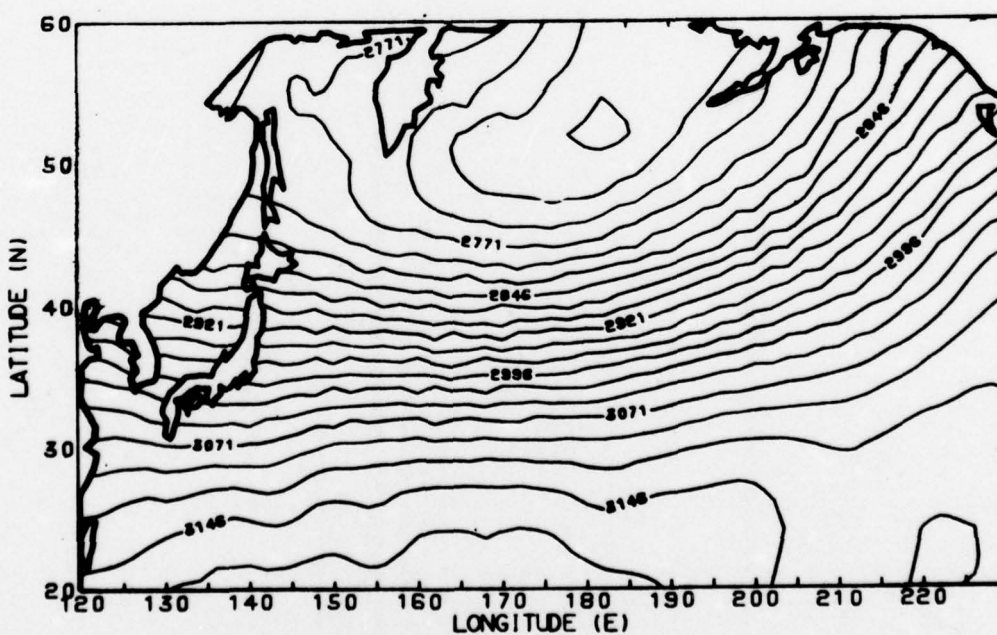


FIGURE 19.8 Monthly mean 700 mb height is the mean of 12-hourly FNWC 700 mb heights. Contour intervals are 25 meters.

VAPOR PRESSURE (MB) DEC 76

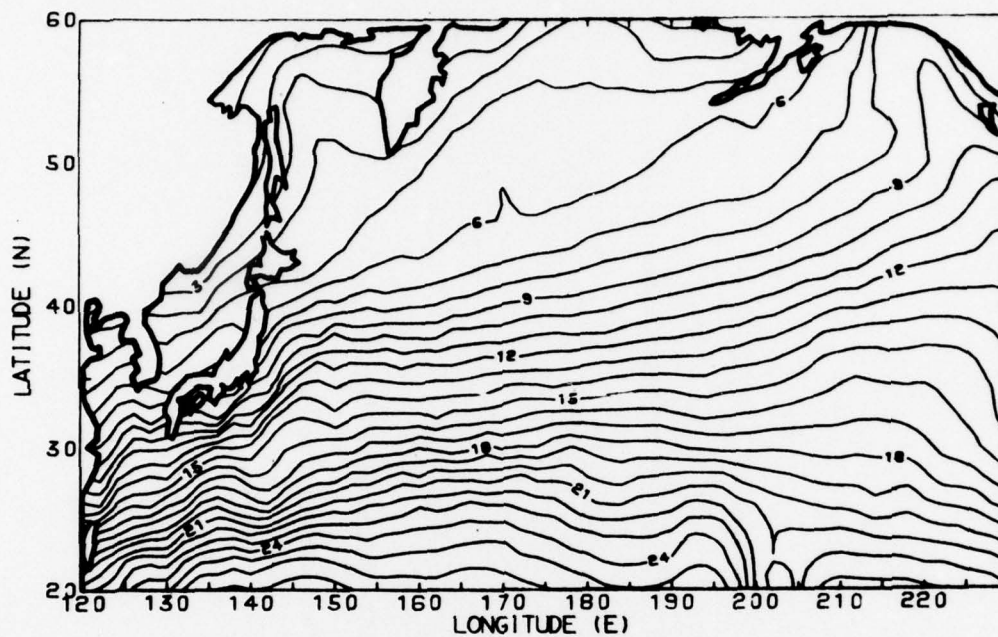


FIGURE 19.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM 2 SEC) DEC 76

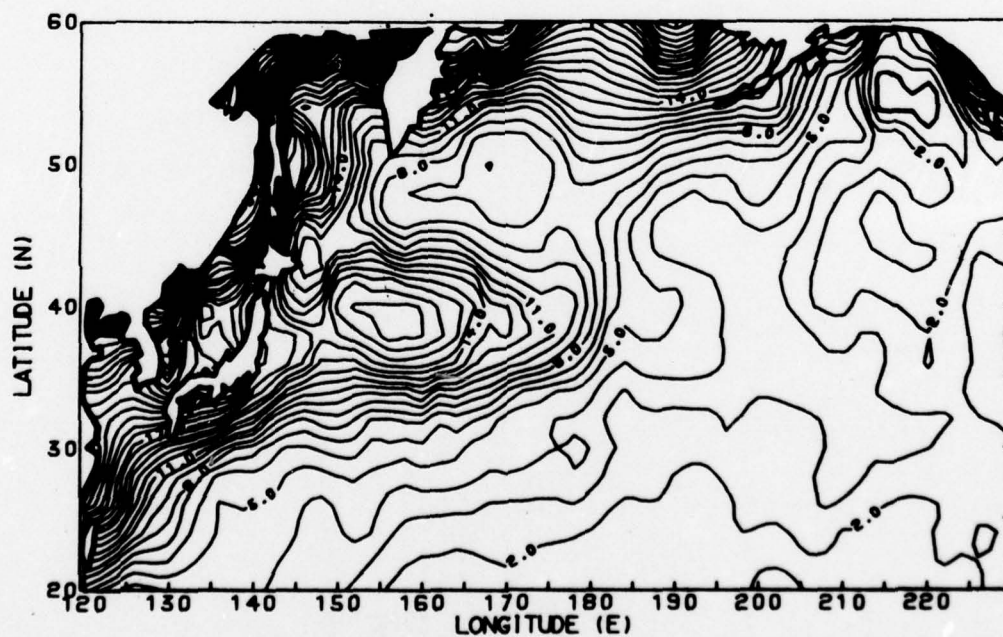


FIGURE 19.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm 2 sec.

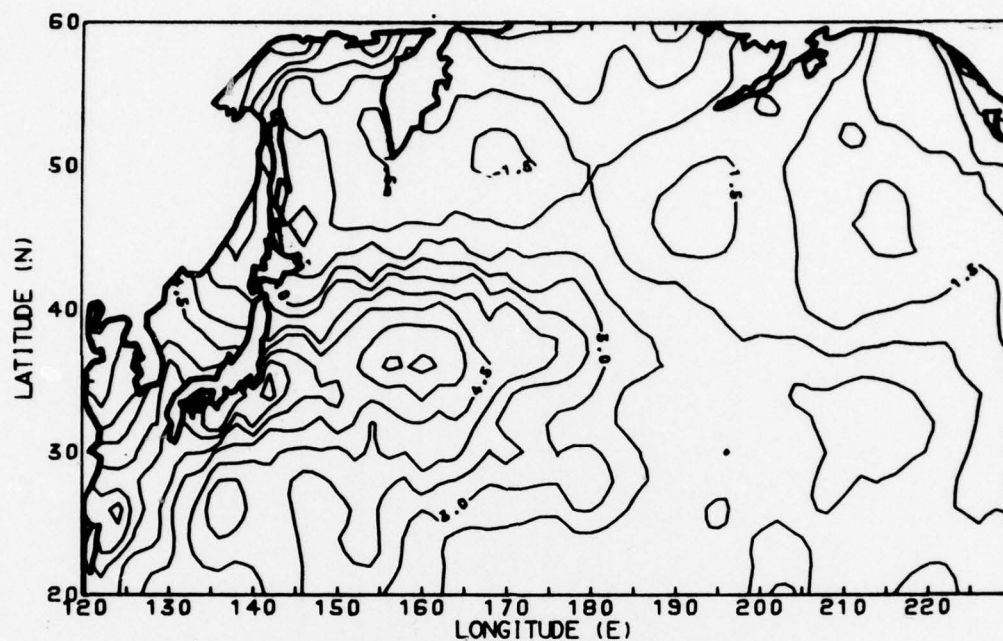


FIGURE 19.11 Monthly mean latent heat flux (ocean to atmosphere) is the mean of 12-hourly latent heat flux calculated from FNWC sea temperature, vapor pressure, and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 0.5×10^{-3} cal/cm 2 sec.

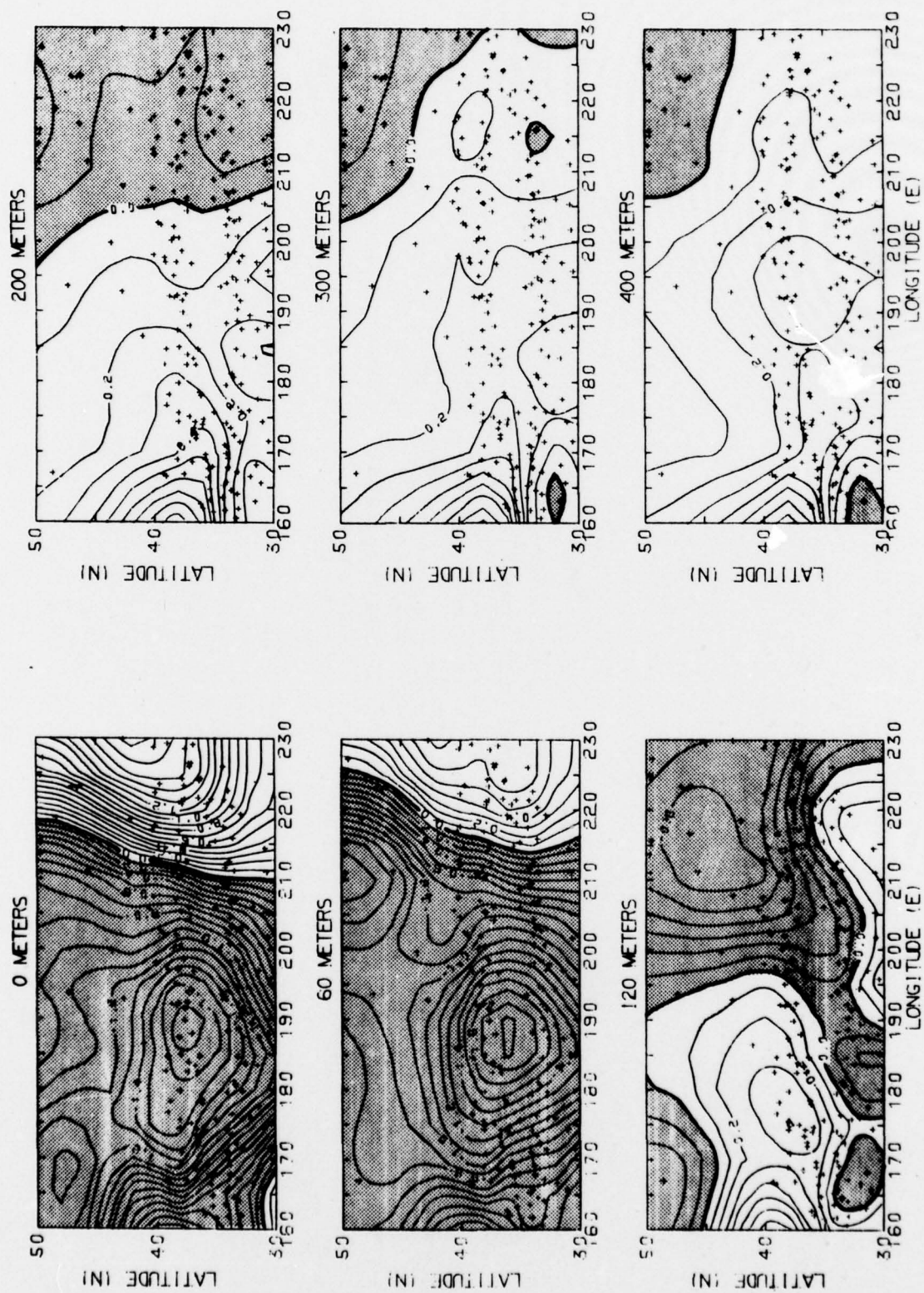


FIGURE 20 Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

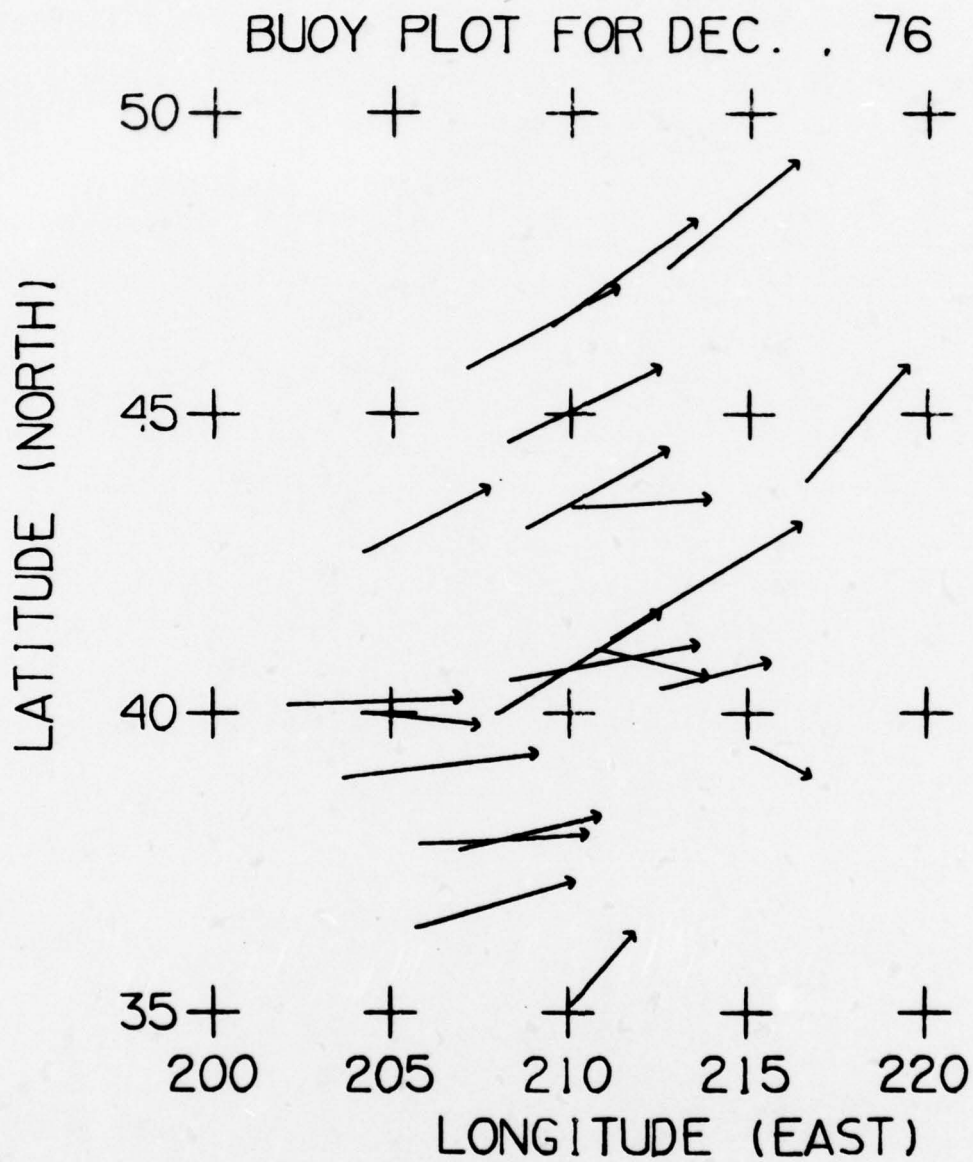


FIGURE 21.

Monthly buoy displacement vectors. Vectors are drawn from start point at beginning of month to terminal point at end of month.

WIND SPEED (M/SEC)

JAN 77

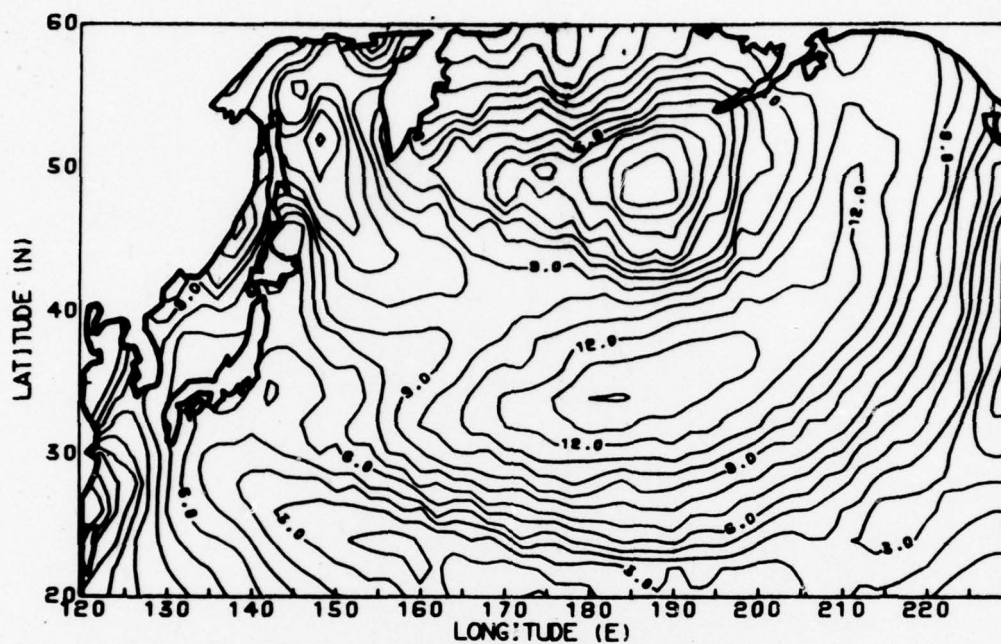


FIGURE 22.1 Absolute value of monthly mean vector wind velocities at 19.5 meters. Contour intervals are 1 m/sec.

WIND DIRECTION

JAN 77

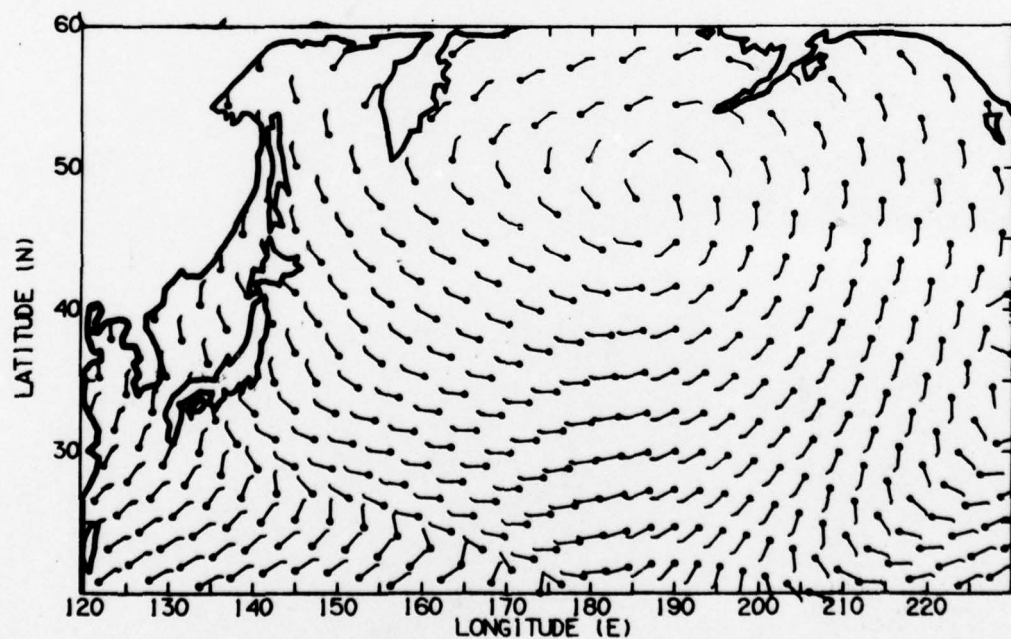


FIGURE 22.2 Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vanes on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

WIND STRESS (DYNES/CM^{••2})

JAN 77

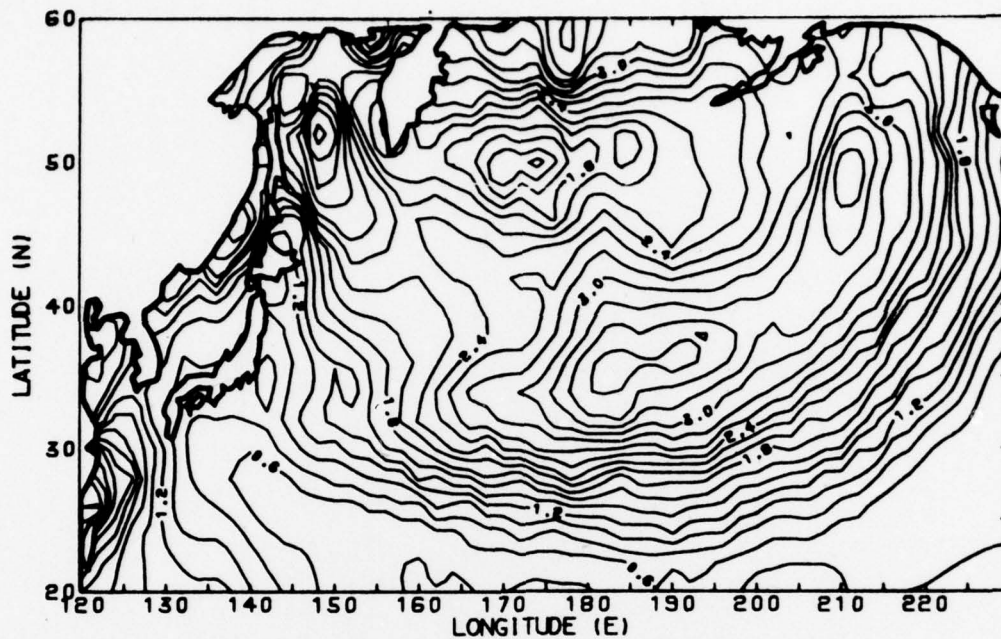


FIGURE 22.3 Monthly mean wind stress is the mean of 6-hourly wind stress at 10 meters calculated from FNWC wind data. Contour intervals are 0.2 dynes/cm^{••2}

CURL OF WIND STRESS (10^{•••9} DYNES/CM^{••3})

JAN 77

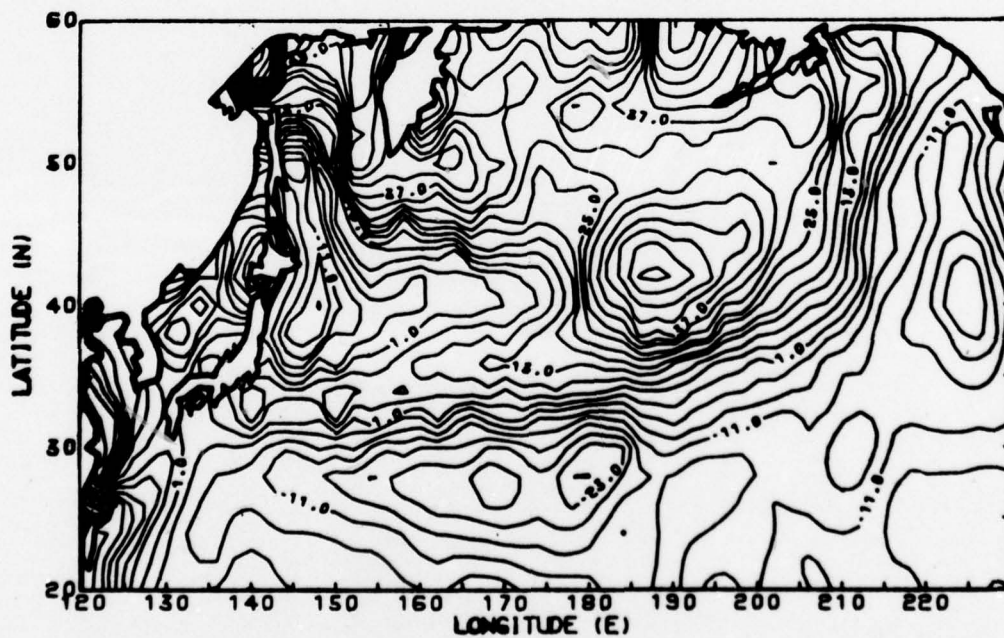
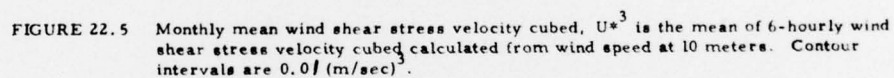
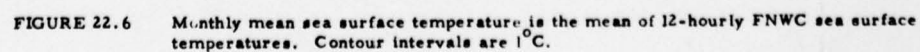


FIGURE 22.4 The vertical component of monthly mean wind stress curl is the mean of 6-hourly wind stress curl approximated by finite-differences from 6-hourly wind stresses at 10 meters. Isolines of zero curl are plotted heavily, and contour intervals are 4.0×10^{-9} dynes/cm^{••3}.

JAN 77



JAN 77



AIR TEMPERATURE (DEG. C) JAN 77

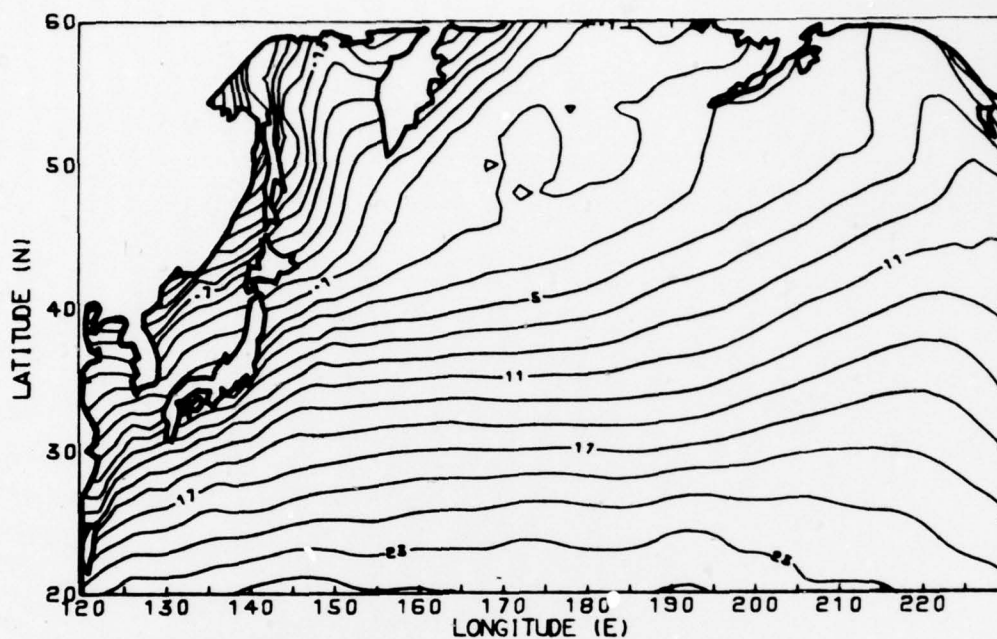


FIGURE 22.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) JAN 77

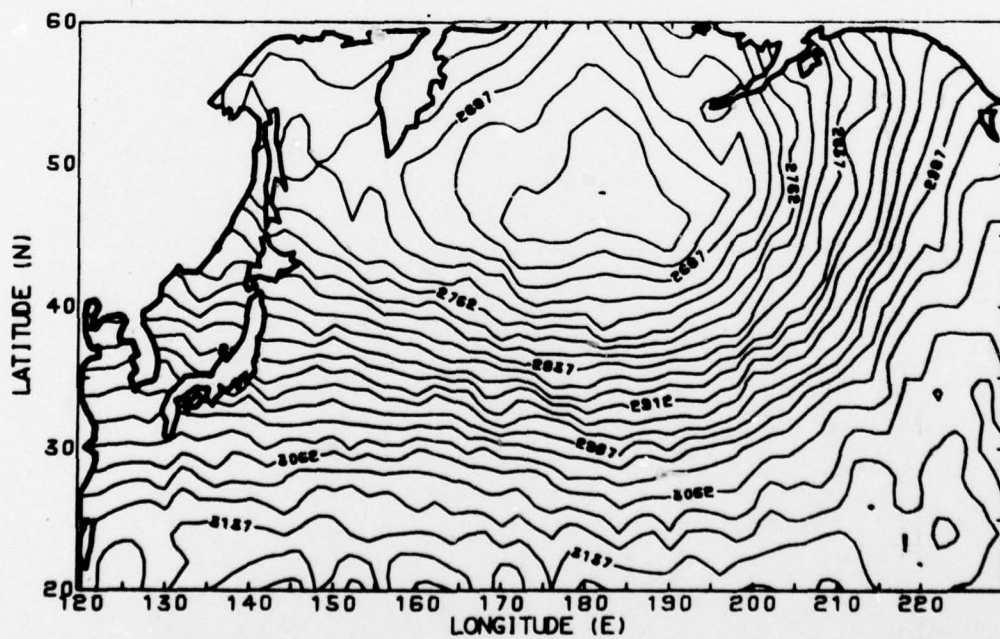


FIGURE 22.8 Monthly mean 700 mb height is the mean of 12-hourly FNWC 700 mb heights. Contour intervals are 25 meters.

VAPOR PRESSURE (MB) JAN 77

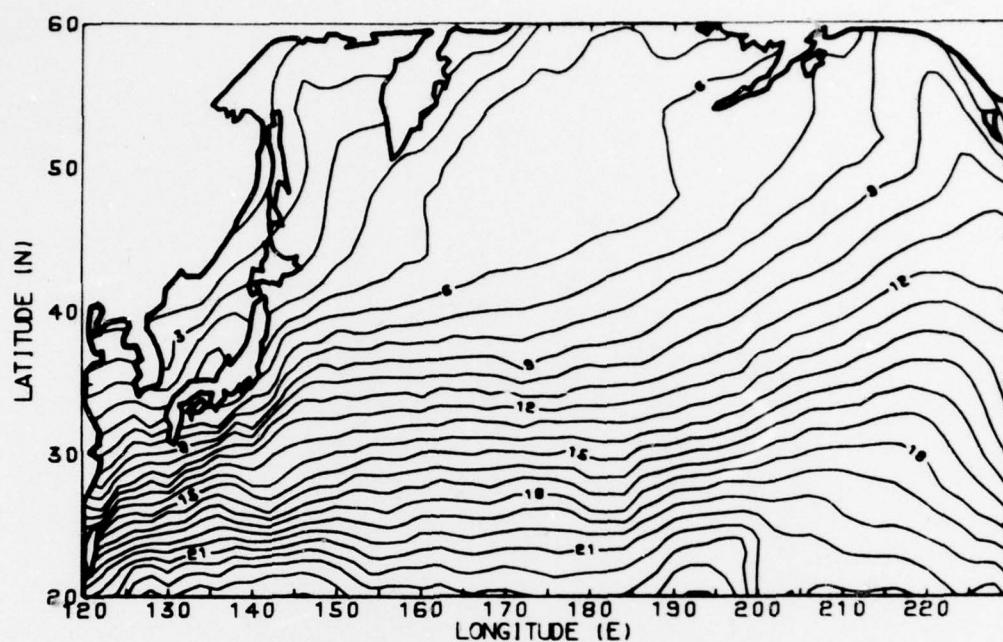


FIGURE 22.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM² SEC) JAN 77

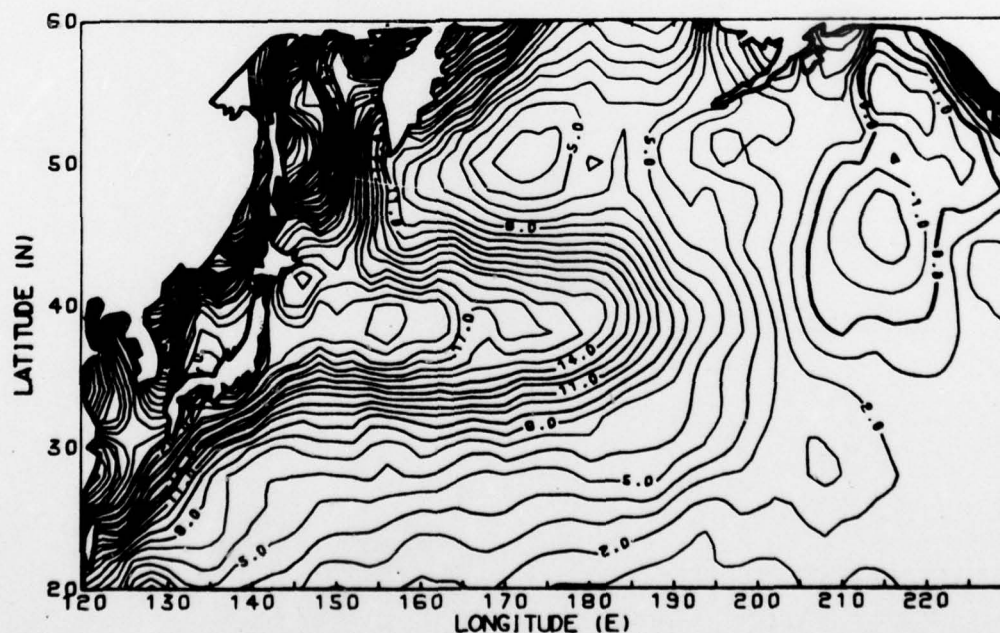


FIGURE 22.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm² sec.

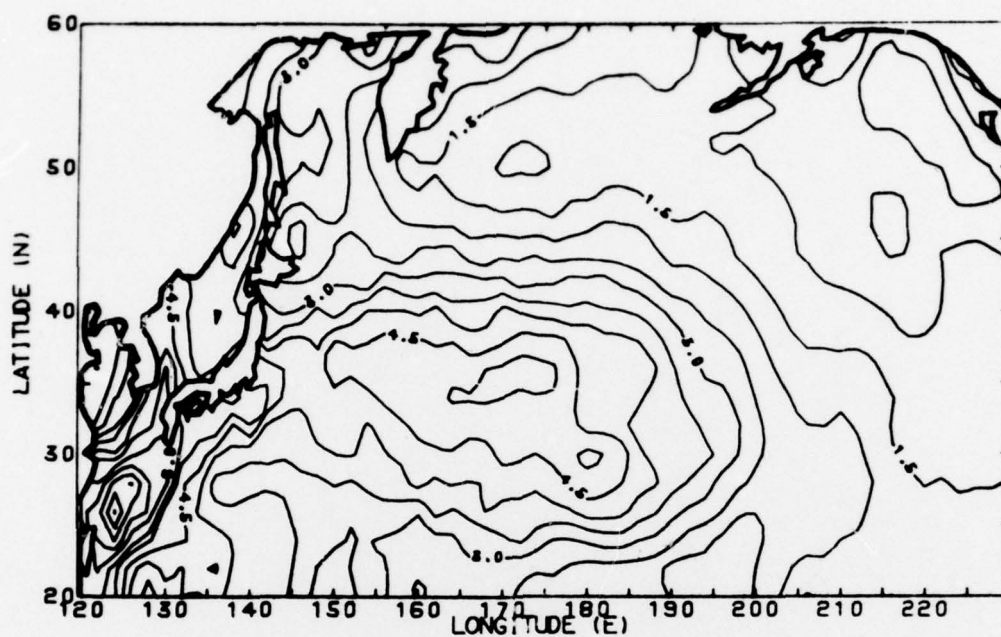


FIGURE 22.11 Monthly mean latent heat flux (ocean to atmosphere) is the mean of 12-hourly latent heat flux calculated from FNWC sea temperature, vapor pressure and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 0.5×10^{-3} cal/cm 2 sec.

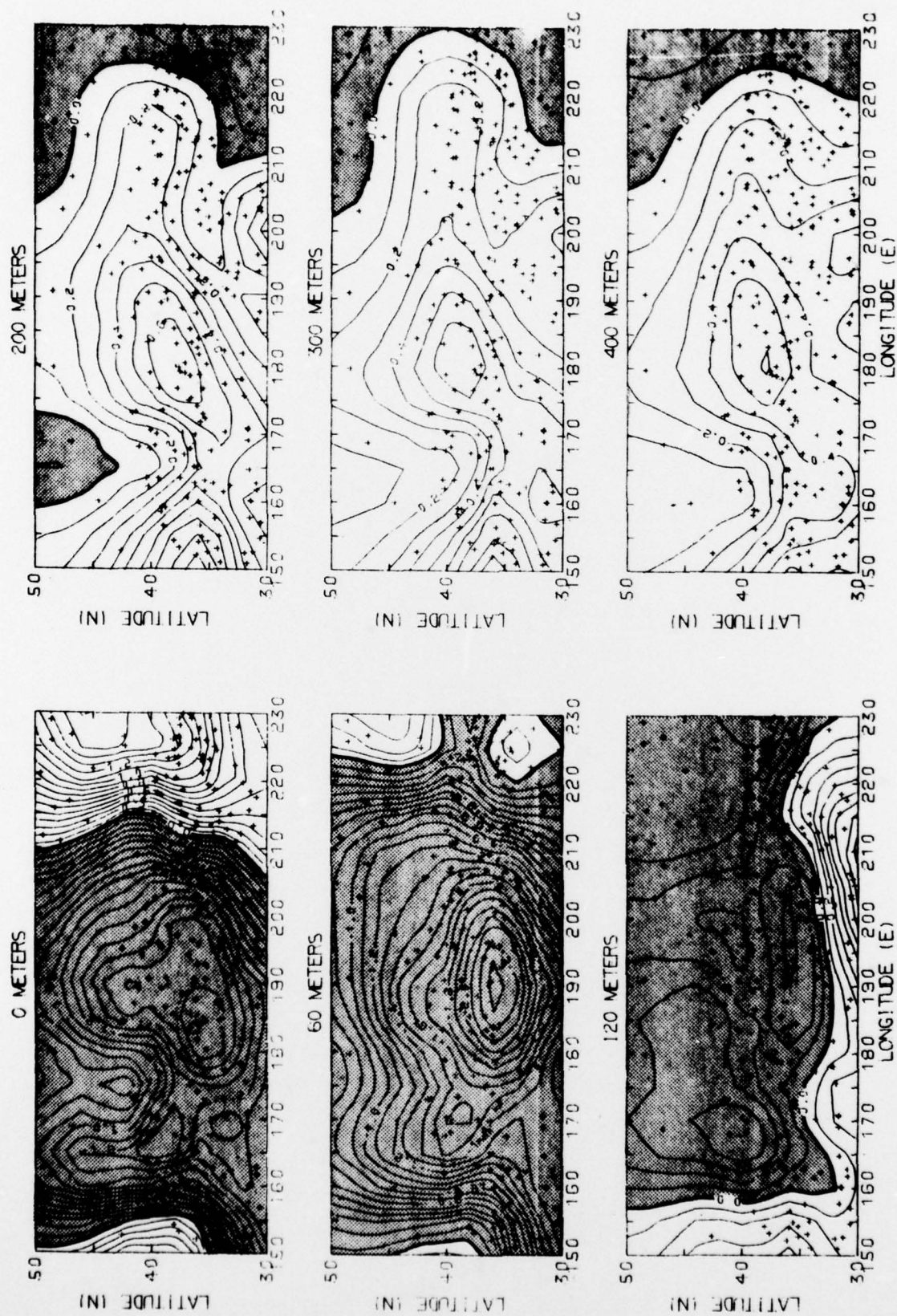


FIGURE 23. Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

WIND SPEED (M/SEC)

FEB 77

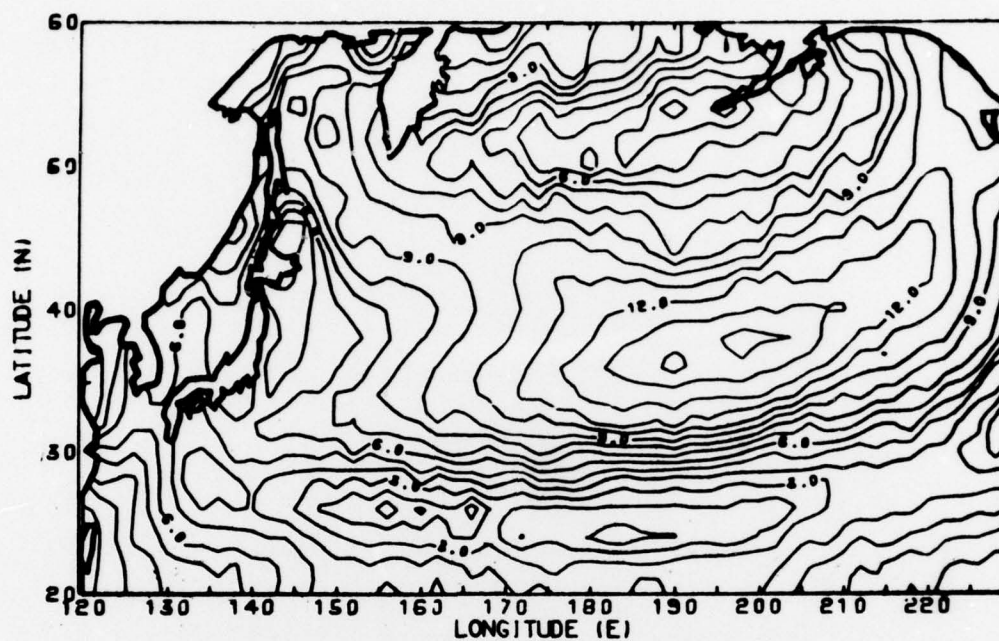


FIGURE 24.1 Absolute value of monthly mean vector wind velocities at 19.5 meters. Contour intervals are 1 m/sec.

WIND DIRECTION

FEB 77

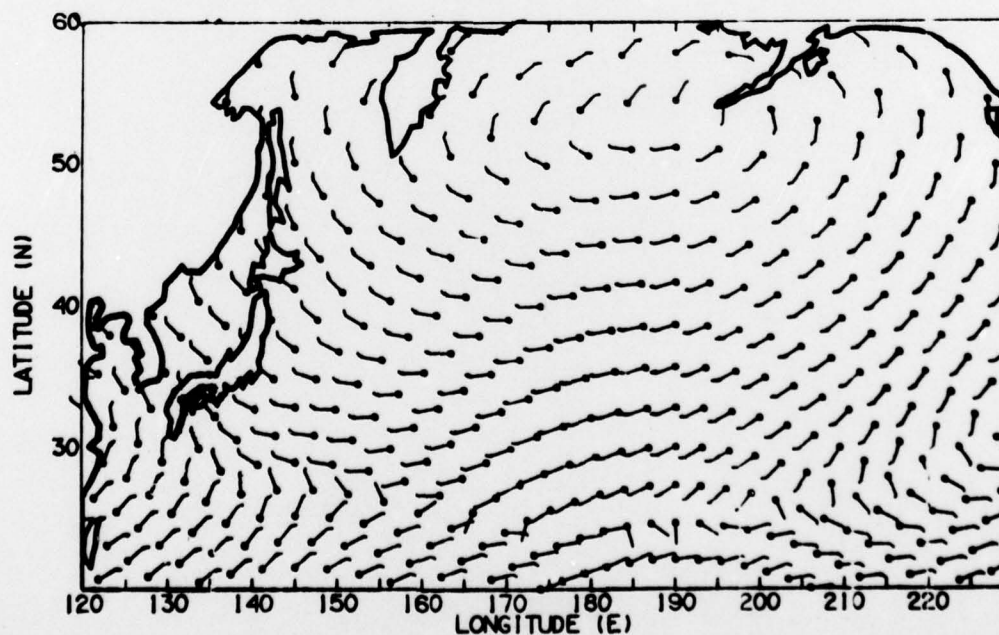
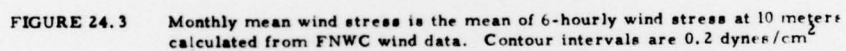
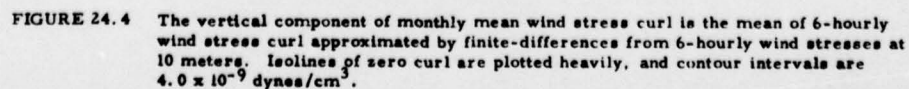


FIGURE 24.2 Direction arrows representing directions of monthly mean wind vectors at 19.5 meters. Vanes on arrows indicate wind speed in knots. If speed is less than 2.5 knots, there is no vane; for every 5 knots above 2.5 knots, 1/2 vane is plotted.

FEB 77



FEB 77



U STAR CUBED ((M/SEC)**3)

FEB 77

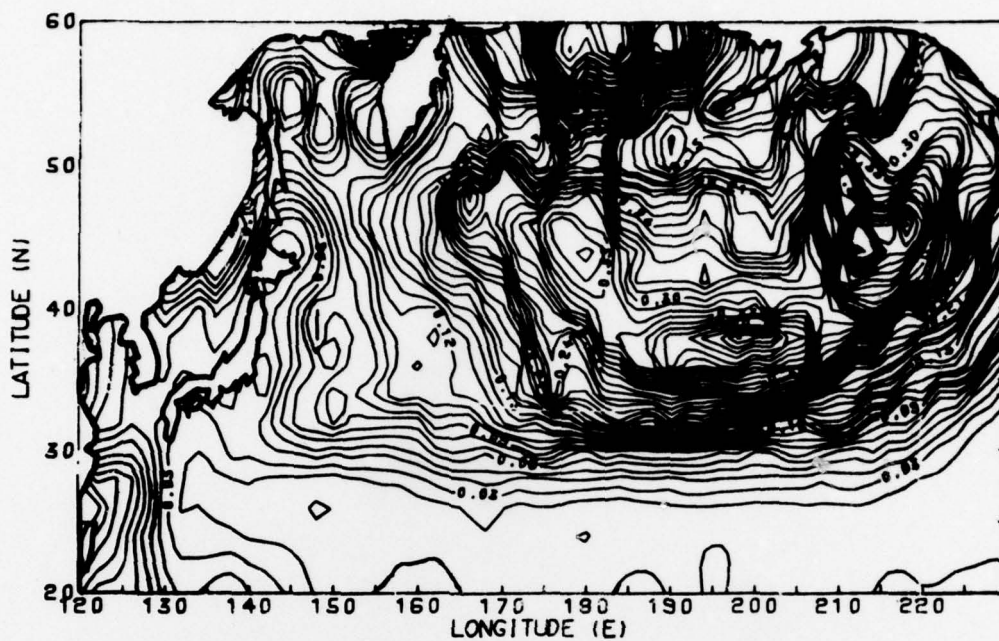


FIGURE 24.5 Monthly mean wind shear stress velocity cubed, U_*^3 is the mean of 6-hourly wind shear stress velocity cubed calculated from wind speed at 10 meters. Contour intervals are 0.01 $(m/sec)^3$.

SEA SURFACE TEMPERATURE (DEG.C)

FEB 77

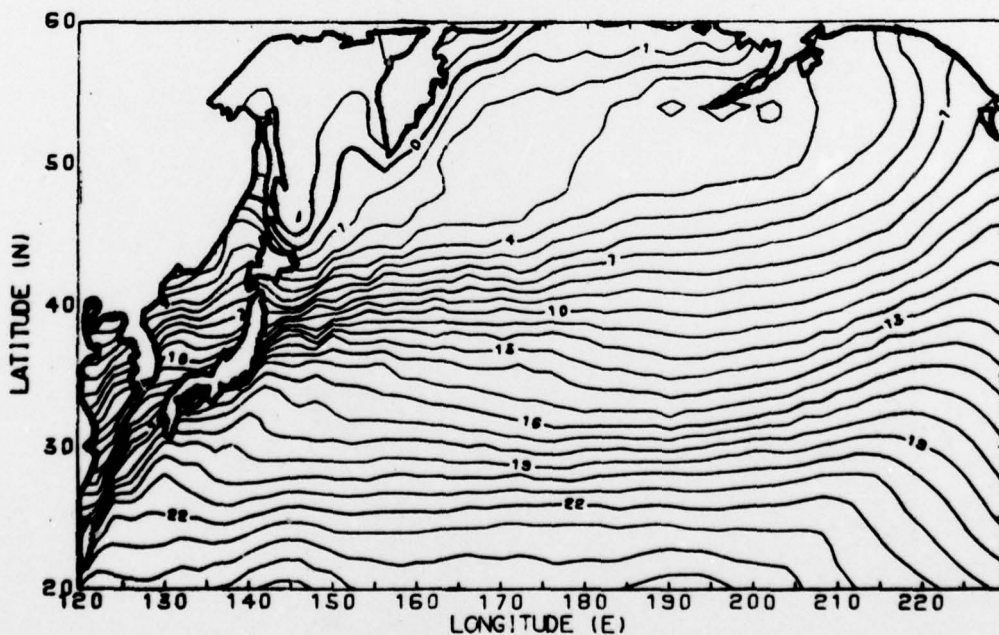


FIGURE 24.6 Monthly mean sea surface temperature is the mean of 12-hourly FNWC sea surface temperatures. Contour intervals are 1°C.

AIR TEMPERATURE (DEG. C) FEB 77

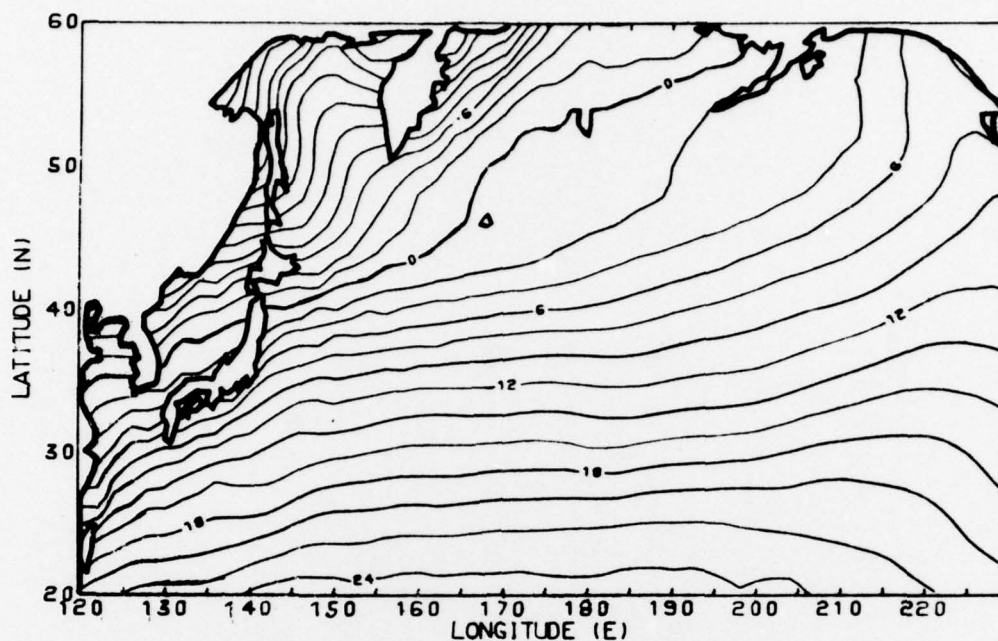
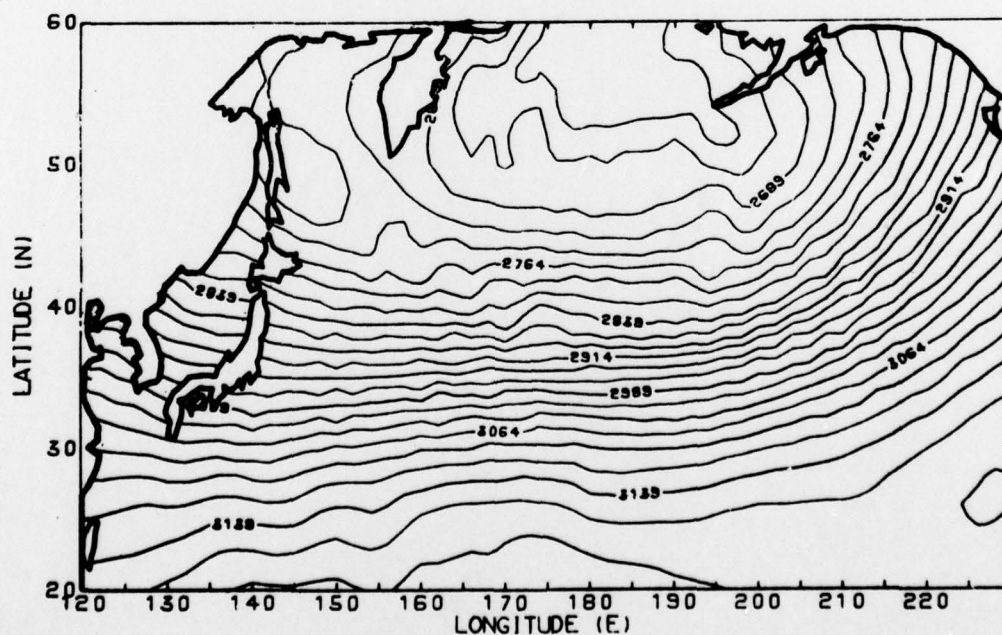


FIGURE 24.7 Monthly mean air temperature is the mean of 12-hourly FNWC air temperatures. Contour intervals are 2°C.

700 MB HEIGHT (M) FEB 77



VAPOR PRESSURE (MB) FEB 77

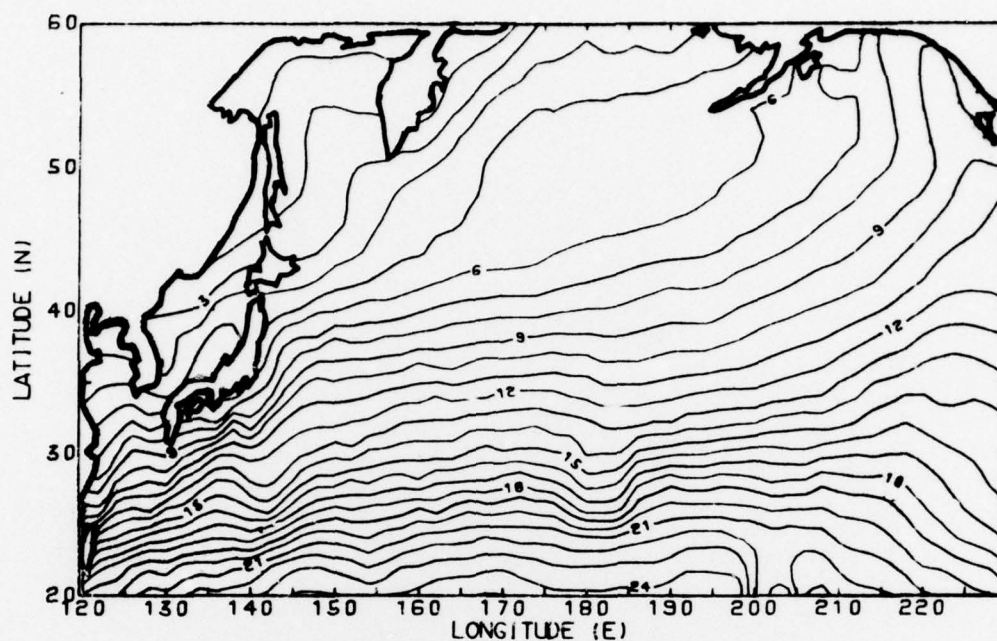


FIGURE 24.9 Monthly mean surface vapor pressure is the mean of 12-hourly FNWC vapor pressure at 19.5 meters. Contour intervals are 1 mb.

SENSIBLE HEAT FLUX (10^{-4} CAL/CM² SEC) FEB 77

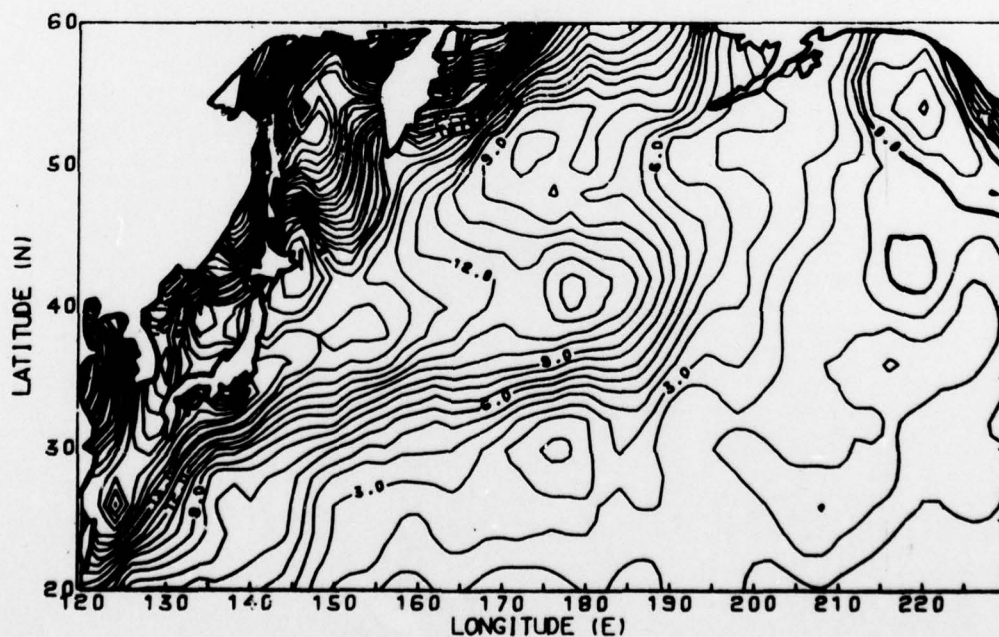


FIGURE 24.10 Monthly mean sensible heat flux (ocean to atmosphere) is the mean of 12-hourly sensible heat flux calculated from FNWC air and sea temperature and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 1.0×10^{-4} cal/cm² sec.

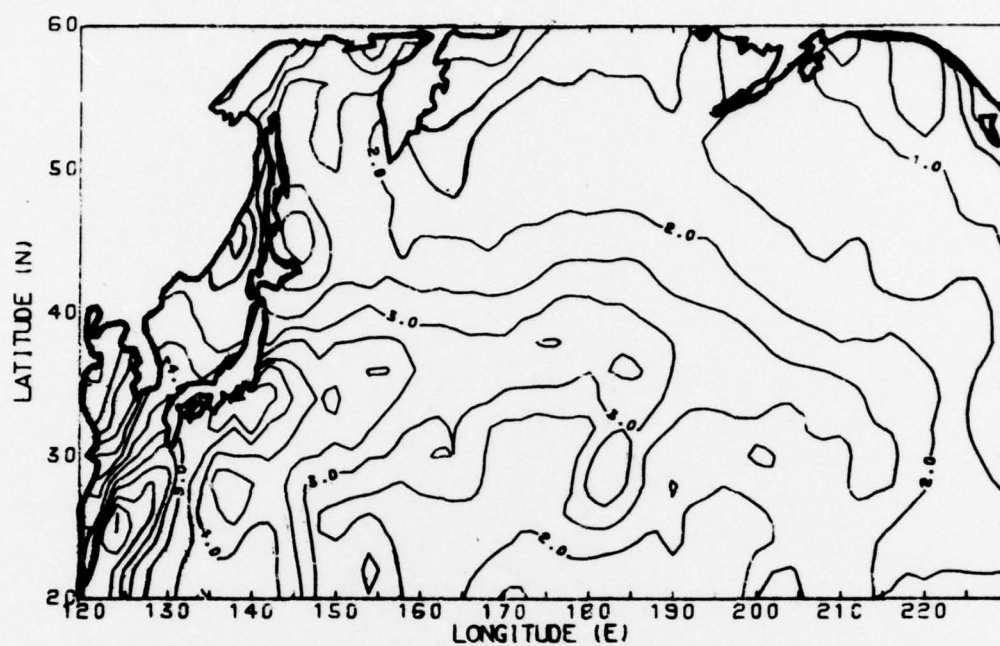


FIGURE 24.11 Monthly mean latent heat flux (ocean to atmosphere) is the mean of 12-hourly latent heat flux calculated from FNWC sea temperature, vapor pressure and wind using a bulk formula. Isolines of zero heat flux are plotted heavily, and contour intervals are 0.5×10^{-3} cal/cm 2 sec.

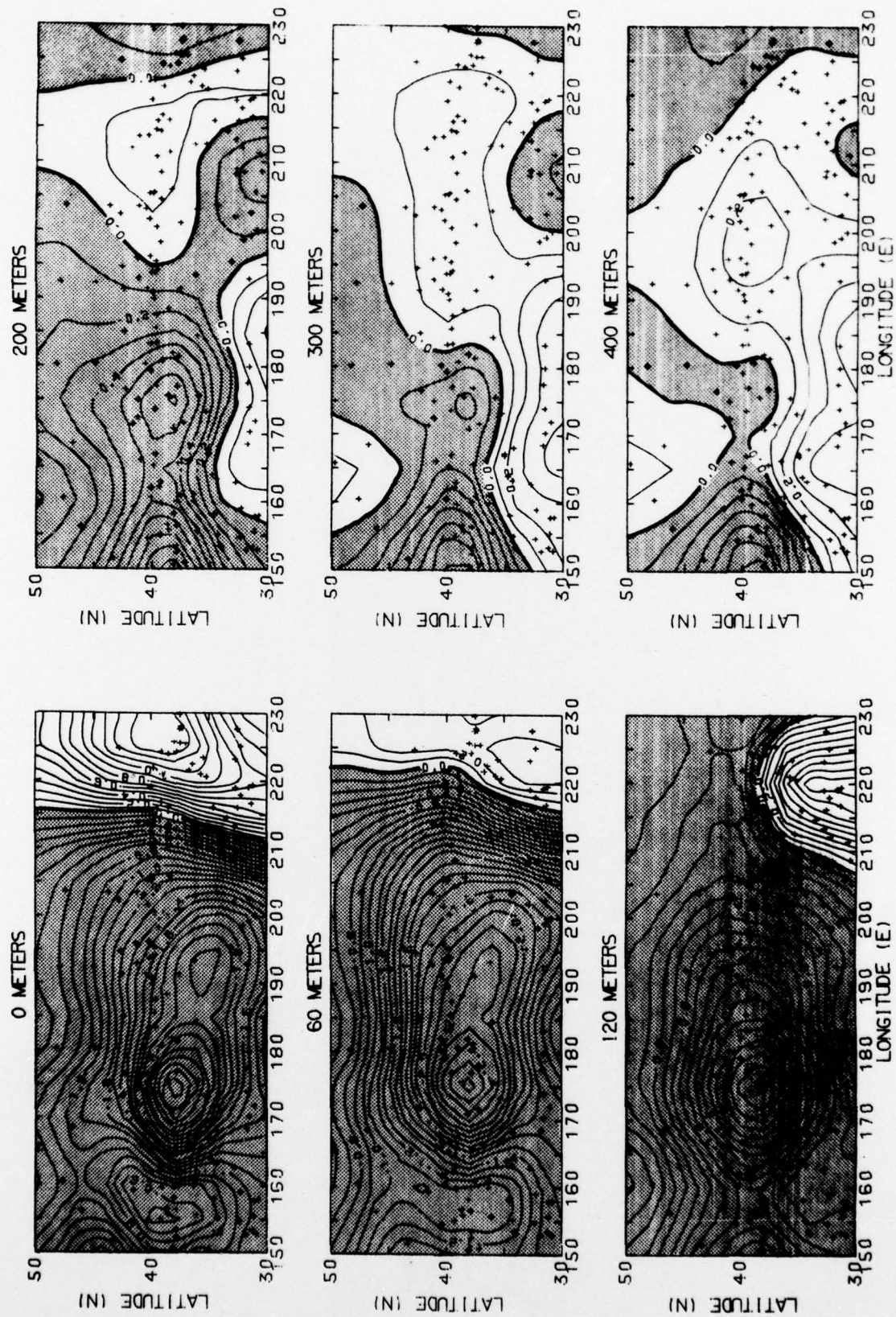


FIGURE 25. Monthly temperature anomalies ($^{\circ}\text{C}$) contoured at fixed depths. Negative anomaly areas are hatched and isolines of zero anomaly are drawn heavily. The crosses mark the positions of the TRANSPAC XBT drops.

APPENDIX A

The vertical component of wind stress curl,

$$\hat{r} \cdot \text{curl } \vec{\tau} = \frac{1}{r} \left(\frac{\partial \tau_{NS}}{\cos \varphi \partial \theta} - \frac{\partial \tau_{EW}}{\partial \varphi} \right), \quad (1)$$

was calculated on the FNWC polar grid using the chain rule and differentiating the polar projection mapping equations,

$$\xi = 32 + 31.205 \cdot \left(\frac{1 - \sin \varphi}{1 + \sin \varphi} \right)^{1/2} \cdot \sin(\theta + 80) \quad (2a)$$

$$\eta = 32 + 31.205 \cdot \left(\frac{1 - \sin \varphi}{1 + \sin \varphi} \right)^{1/2} \cdot \cos(\theta + 80), \quad *(2b)$$

where

τ_{NS} = north-south component of wind stress

τ_{EW} = east-west component of wind stress

φ = latitude

θ = longitude

r = earth radius

ξ = horizontal axis of rectilinear
grid on a polar projection
in Figure 1

η = vertical axis of grid in Figure 1.

Finite difference expressions for equation (1) were:

* The factors in this equation, 33 and 31.205, are specific to FNWC's 63 x 63 grid.

$$\frac{\partial \tau_{NS}}{\partial \theta} = \frac{1}{2} (\tau_{NS_{i+1,j}} - \tau_{NS_{i-1,j}}) \frac{\partial \xi}{\partial \theta} + \frac{1}{2} (\tau_{NS_{i,j+1}} - \tau_{NS_{i,j-1}}) \frac{\partial \eta}{\partial \theta} \quad (3a)$$

$$\frac{\partial \tau_{EW}}{\partial \varphi} = \frac{1}{2} (\tau_{EW_{i+1,j}} - \tau_{EW_{i-1,j}}) \frac{\partial \xi}{\partial \varphi} + \frac{1}{2} (\tau_{EW_{i,j+1}} - \tau_{EW_{i,j-1}}) \frac{\partial \eta}{\partial \varphi} \quad (3b)$$

where

i = 0, ..., 62; discrete values of ξ

j = 0, ..., 32; discrete values of η .

When equations (3a) and (3b) were substituted into equations (2a) and (2b), a finite difference expression for the vertical component of wind stress curl was obtained:

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